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A HILL FARM IN WALES (NINE YEARS' FINANCIAL RESULTS.)

By J. PRYSE HOWELL, M.Sc.,
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This hill farm, situated in one of the upland districts of Wales, is typical of much of the farming in the Principality. Natural conditions in these regions are such that production is almost entirely confined to the raising of store cattle and sheep along with a few pigs and poultry. Soil and climatic conditions are not favourable for the growing of crops and the greater part of the land is under rough grass and permanent pasture. Such tillage land as there is, however, is used for the growing of some oats and roots for the feeding of livestock and sufficient potatoes for household requirements. The system of farming in these areas continues much the same from year to year. The choice of farm enterprises are few and there is but very little scope for any drastic change in the farming practice to meet the changing demands of the market. Some indication of how these hill farmers have fared during the years 1929-30 to 1937-8 is afforded by the records of the upland farm on which this study is based.

The farm to which the accounts relate is situated in a poor and exposed district, and is about seven miles from a market centre and railway station. The homestead stands at about 850 feet above sea level and including the open mountain, the land rises to an altitude of about 1,300 feet. The farm comprises 81 acres of land which is practically all enclosed and owned by the occupier. The assessed rent is £50 or approximately 12s. 4d. per acre. Up to 1934 there was in addition 100 acres of mountain land for which a rental of £7 10s. 0d. or 1s. 6d. per acre was paid. In that year the tenancy of this land was terminated and 170 acres of similar land was taken on at the same rental. The total area of the farm up to 1934 was therefore 181 acres and from that year onwards 251 acres.

Owing to the poor natural conditions arable crops are of little importance. Some oats are grown but the area under this crop did not exceed 13 acres in any year and in some years was as low as 7½ acres. Other arable crops cultivated were swedes and potatoes and taking both crops together the acreage grown in any year did not exceed one acre. Land mowed for hay varied from 21 to 23 acres. Over the whole period the utilization of the land was approximately as follows—arable crops 5 per cent, hay 11 per cent, permanent pasture 22 per cent, and rough grazing 62 per cent.

There was a very good herd of Welsh Black Cattle kept, and eight to nine dairy cows were maintained. In addition to the calves bred a few were bought in each year for rearing. Butter making was combined with calf rearing. Cattle sales consisted of one or two draft cows or down calving heifers but mainly of store cattle varying from twelve to twenty months old. Sales of cattle were usually in the spring and autumn. In the last three years some bull calves were sold at fairly good prices.

A flock of about 100 Welsh mountain ewes was kept and, including the yearling ewes and rams, the number of adult sheep kept varied from about 130 to 140 between one year and another. Sales were of draft ewes and store lambs but occasionally some lambs were fattened.

Pigs were never an important part of the farming system. During the early part of the period to which these accounts relate, a breeding sow was kept and the progeny sold as weaners. This was changed over to a policy of buying-in weaners and selling out as forward stores or porkers. In the last three years, purchases of pigs were confined to the buying of one or two weaners to provide the household with bacon.

Up to 1933 a small flock of about 50 laying birds was kept. Some attempt was then made to concentrate more on poultry and stocks were increased to about one hundred laying birds. Difficulty of rearing together with other causes led to a considerable decline in the poultry stock in the last two years. The exposed condition of the farm was not favourable to any great development in the poultry enterprise.

There were two horses kept for farm work and these represented the total number of horses on the farm in most years. Sales of horses were therefore of minor importance.

The nature of the land, together with the type of farming followed did not call for much employment of labour. With the assistance of one hired man and a little casual labour at busy times the occupier and his wife were able to cope with the work. The farmer can be regarded as being fully employed in manual work on the farm while one-third of the time of the wife was utilised in doing work of this character. Total regular labour on the farm was therefore the equivalent of about 2⅓ persons.

On the basis of the mean of opening and closing valuation the average capital invested in the farm over the whole period was £605, with variations between £571 and £633. As the revenue was almost entirely derived from the sales of livestock and livestock products the bulk of the farm capital was invested in livestock.

Some indication of the relative importance of the various farm products sold can be seen from the following figures which give the percentage composition of the farm receipts on a nine-year's basis :—

Percentage Composition of Receipts (Nine Years Average).

Commodity.	*Per cent.*	*Commodity.*	*Per cent.*
Cattle	29.5	Poultry and Eggs	12.5
Butter	20.0	Horses	1.3
Milk	5.1	Crops and Sundries	3.5
Sheep and Wool	22.0		
Pigs	6.1	Total	100.0

The proportions which the different farm products bear to total sales vary to some extent from year to year. The degree of variation was partly influenced by price changes and partly by the quantity of the commodity produced. It is clear from the records, however, that the major part of the receipts in all years were obtained from the sales of cattle, butter, sheep and wool.

Receipts.

The receipts on this farm declined very rapidly between 1929-30 and 1932-3 and total sales dropped by 45 per cent. Some recovery was made in 1933-4 and this improvement continued more or less steadily up to 1937-8 but receipts were still 12 per cent below those in 1929-30. (See Tables I and II.)

An examination of the different items comprising the receipts indicate that sales of cattle kept comparatively steady between 1929-30 and 1931-2,—the decline in sales being only 3 per cent. In the following two years, however, the reduction in sales was very severe and particularly so in 1933-4, when receipts from cattle were only about £36 as compared with £151 in 1929-30—a decline of 76 per cent. Conditions improved in the following year when sales increased to £125, but in 1935-6 they were down to £92. Sales increased in 1936-7 to about £103 and again in 1937-8 to about £108 when they stood at 28 per cent below the receipts in 1929-30. But the variation in the receipts from cattle are not wholly due to changes in prices as it is evident from the records that they are also influenced by the number and class of cattle sold. (See Table III).

Receipts from butter showed a considerable decline between 1929-30 and 1932-3, the fall amounting to nearly £77 or 67 per cent. This was followed by a steady improvement up to 1937-38 when receipts were about £94 as compared with £113 in 1929-30. Receipts are influenced by the price and the quantity of butter produced. The quantity produced will be largely determined by the number

TABLE I.

Receipts.

Year.	*Total Receipts.*	*Cattle.*	*Butter.*	*Milk.*	*Sheep & Wool.*	*Pigs.*	*Poultry & Eggs.*	*Horses.*	*Total Livestock and Livestock Products.*	*Crops & Sundries.*	*Produce Consumed (Included in Receipts)*
	£	£	£	£	£	£	£	£	£	£	£
1929–30	500.0	150.7	113.0	29.0	117.0	51.8	27.9	—	489.4	10.6	71.8
1930–31	436.1	150.0	82.9	18.6	140.1	12.0	22.6	—	426.2	9.9	52.9
1931–32	362.9	147.0	64.6	18.4	71.4	32.6	18.3	—	352.3	10.6	55.8
1932–33	276.0	90.1	37.3	13.0	57.6	12.5	30.8	22.0	263.3	12.7	44.6
1933–34	310.9	35.8	69.3	18.8	46.2	39.3	67.6	21.0	298.0	12.9	60.7
1934–35	370.5	124.5	62.2	18.5	56.5	18.4	75.8	—	355.9	14.6	48.1
1935–36	354.7	92.0	68.0	18.3	86.6	19.7	57.8	—	342.4	12.3	55.6
1936–37	380.9	102.5	85.5	18.2	90.1	10.0	58.2	—	364.5	16.4	56.3
1937–38	391.5	108.5	93.7	18.4	79.3	12.0	62.8	—	374.7	16.8	67.7
Average (All Years)	375.9	111.2	75.2	19.0	82.8	23.1	46.9	4.8	363.0	12.9	57.1

TABLE II.

Percentage Increase or Decrease in Receipts (Base 1929–30=100).

Year.	*Total Receipts.*	*Cattle.*	*Butter.*	*Milk.*	*Sheep & Wool.*	*Pigs.*	*Poultry & Eggs.*	Total *Livestock and Livestock Products.*	*Crops & Sundries.*
1929–30	% 100	% 100	% 100	% 100	% 100	% 100	% 100	% 100	% 100
1930–1	87	99	73	64	120	23	81	87	94
1931–2	73	97	57	64	61	63	66	72	100
1932–3	55	60	33	45	49	24	110	54	120
1933–4	62	24	61	66	39	76	242	61	122
1934–5	74	83	55	64	48	35	272	73	138
1935–6	71	61	60	63	74	38	207	70	116
1936–7	76	68	76	63	77	19	209	74	155
1937–8	78	72	83	63	68	23	225	77	160

TABLE III.

Number of Cattle sold and average price per head.

Year.	Cows sold.	Average price per head.		Other Cattle sold.	Average price per head.		Calves sold.	Average price per head.		Total Cattle sold.	Average price per head.		Cattle Receipts (Index 1929–30 =100)	Calves bought.
	No.	£	s.	No.	£	s.	No.	£	s.	No.	£	s.		No.
1929–30	1	13	0	13	10	12	—	—		14	10	15	100	3
1030–1	1	13	10	12	11	7	—	—		13	11	11	99	7
1931–2	4	16	5	7	11	14	—	—		11	13	7	97	2
1932–3	2	11	0	7	9	15	—	—		9	10	0	60	—
1933–4	—	—		4	7	12	2	2	13	6	5	19	24	3
1934–5	2	12	0	10	9	16	1	2	10	13	9	11	83	6
1935–6	—	—		11	7	9	1	10	0	12	7	13	61	5
1936–7	2	9	5	8	8	15	1	14	0	11	9	6	68	4
1937–8	1	15	0	6	10	12	2	15	0	9	12	1	72	3

of cows in the herd and the yield of milk. Again yield will depend, to some extent, on the condition of the pastures for summer grazing and the quality of home-grown foods for winter feeding. Unfortunately the quantity of butter produced is not available for 1929-30 and 1930-1 but quantities and prices are stated for the remaining years. (See Table IV). The low production of butter in 1932-3 may be attributed partly to a slight reduction in the number of cows in the herd during that year, and partly to the poor feeding value of pastures during the grazing season. Production remains very much the same between 1933-4 and 1935-6 and in the two following years some increase is noticeable. Production from 1933-4 onwards appears to follow fairly closely the trend in the number of cows kept in the herd. The price of butter continued to fall up to 1934-5 when it was 4d. per lb. lower than in 1931-2. Prices improved steadily in the following three years and in 1937-8 averaged slightly over 15¼d. per lb.

As regards income from sheep and wool, the best year experienced by this farmer was 1930-1 when sales amounted to slightly over £140, or about one-third of the total farm receipts. The worst year was 1933-4 when returns from the flock only reached slightly over £46. There was some recovery in 1934-5 and this continued up to 1936-7 when sales were about £90. This was followed by a decline in 1937-8 and sales dropped to slightly over £79. The prices realised per head for the draft ewes and lambs, together with the number sold each year are given in Table V.

TABLE IV.

Quantities of Butter produced and price per lb.

Year.	*Quanity of Butter produced.*	*Price per lb.*	*Receipts from Butter (Index 1929-30 = 100).*
	lbs.	*Pence.*	
1929-30	—	—	100
1930-1	—	—	73
1931-2	967	16.0	57
1932-3	576	15.5	33
1933-4	1,282	12.9	61
1934-5	1,239	12.0	55
1935-6	1,233	13.2	60
1936-7	1,516	13.5	76
1937-8	1,468	15.3	83

TABLE V.

Number of sheep sold and average price per head.

Year.	*Lambs sold.*	*Average price per head.*		*Breeding Ewes sold.*	*Average price per head.*		*Rams. sold.*	*Average price per head.*		*Total Sheep sold.*	*Receipts from Sheep and Wool (Index 1929-30 = 100.)*
	No.	*s.*	*d.*	*No.*	*s.*	*d.*	*No.*	*s.*	*d.*	*No.*	
1929–30	33	31	7	28	34	5	—	—		61	100
1930–1	49	31	3	25	45	3	3	46	0	77	120
1931–2	35	19	8	25	27	6	1	50	0	61	61
1932–3	37	13	5	24	16	6	—	—		61	49
1933–4	41	18	10	—	—		—	—		41	39
1934–5	9	23	1	30	25	0	—	—		39	48
1935–6	30	24	6	30	27	0	—	—		60	74
1936–7	30	21	2	31	28	6	1	30	0	62	77
1937–8	22	23	6	30	31	0	3	36	1	55	68

While the number of breeding ewes kept on this farm remained practically the same from year to year the number of sheep sold varied from 39 in 1934-5 to 77 in 1930-1. This was to be expected as the number for sale would be largely determined by the number of lambs reared and the rate of mortality amongst the flock. It is evident from the records that the number of lambs reared in relation to the number of ewes kept varied from year to year and that losses from deaths were heavy in some years.

It will be observed that there was a very heavy fall in the prices realised for the lambs between 1929-30 and 1932-3, and particularly after 1930-1. The sale price of lambs averaged 31s. 7d. per head in 1929-30 as compared with 13s. 5d. in 1932-3. The price rose to 18s. 10d. per head in 1933-4 and contained to rise in the next two years, but declined again in 1936-7 to 21s. 2d. There was some improvement in 1937-8 when the lambs averaged 23s 6d. per head which was 9s 1d. below the price realised in 1929-30. The highest price realised for breeding ewes was in 1930-1 when they averaged 45s. 3d. each, but prices fell very rapidly in the following two years,—the price realised in 1932-3 being 16s 6d. per head. There were no sales of breeding ewes in 1933-4. In 1934-5 they averaged 25s. a piece and prices continued to improve up to 1937-8 when they were sold at 31s. each.

Pig sales were variable and did not show any definite trends. As already stated sales included value of pigs consumed in the farm house. In some years they have contributed a fair sum to the farm receipts but in most years the proportion of pig sales to total receipts was small.

In the first three years (1929-32) sales of poultry and eggs were of minor importance but in the following years more attention was given to poultry with the result that receipts from this enterprise were considerably increased. Records of the number of birds (sold and used for consumption) and the eggs produced are not available for 1929-30 and 1930-1 but the data for the remaining years is given in Table VI.

The drop in poultry receipts between 1929-30 and 1931-2 was almost entirely due to the decline in the price of eggs as the number of laying birds on the farm remained fairly constant during this period. With the increase in the flock which started about 1932-3, the receipts from poultry more than doubled in the following year, and there was a further increase in 1934-5 when receipts amounted to nearly £76 as compared with about £28 in 1929-30. The decline in output of birds and eggs which occurred after 1934-5 can be traced to a reduction in the size of the flock. The prices realised for poultry do not show any definite trend. Egg prices showed a

TABLE VI.

Number of Poultry (sold and consumed) and Eggs produced.

Year.	*Poultry sold and consumed.*	*Average Price (per head).*	*Eggs produced.*	*Average price per dozen.*	*Receipts from Poultry and Eggs (Index 1929—30 = 100)*
	No.	*s. d.*	*No.*	*Pence.*	
1929-30	—	—	—	—	100
1930-1	—	—	—	—	81
1931-2	29	2 6	3,443	12.2	66
1932-3	65	2 11	4,668	13.2	110
1933-4	133	3 6	10,399	12.3	242
1934-5	221	2 9	10,488	12.4	272
1935-6	133	2 10	7,748	14.4	207
1936-7	84	2 6	9,018	15.2	209
1937-8	86	3 10	7,416	18,0	225

continuous improvement between 1933-4 and 1937-8 (particularly from 1934-5 onwards) and reflect the general trend of prices of eggs during that period.

Horse sales were not important and during the whole period only two were sold. Receipts from crops represented almost entirely the value of produce consumed in the farm house. Other than the sale in some years of a few potatoes there were no direct sales of crops.

Expenses.

Expenses varied considerably and although some items remained fairly constant over the whole period, others showed considerable variation from year to year. In 1930-1 total expenses increased by 35 per cent over the previous year, then declined until in 1932-3 they were again at about the same level as in 1929-30. Between 1932-3 and 1933-4 they rose sharply by 57 per cent, then declined in the following three years and in 1936-7 were 10 per cent below the expenses in 1929-30. (See Tables VII and VIII).

Percentage Composition of Expenses (Nine Years Average).

Item.	*Per cent.*	*Item.*	*Per cent.*
Rent	26.8	Seeds	3.2
Rates	1.7	Implements	3.1
Wages	30.4	Sundries	5.2
Feedingstuffs	17.8	Livestock bought	9.0
Manures	2.8		
		Total	100.0

TABLE VII.

Expenses.

Year.	*Total Expenses.*	*Rent.*	*Rates.*	*Wages (Hired).*	*Feeding-stuffs.*	*Manures.*	*Seeds.*	*Imple-ments.*	*Sundries.*	*Total Direct Expenses.*	*Live-stock Bought.*
	£	£	£	£	£	£	£	£	£	£	£
1929–30	180.4	57.5	10.1	56.8	33.3	—	1.2	1.5	13.8	174.2	6.2
1930–1	243.6	57.5	5.3	68.4	37.6	13.3	9.3	6.5	10.8	208.7	34.9
1931–2	207.2	57.5	2.8	67.7	34.1	14.7	11.6	8.1	4.2	200.7	6.5
1932–3	182.9	57.5	2.1	61.6	33.4	—	13.3	0.9	14.1	182.9	—
1933–4	283.3	57.5	2.1	76.6	71.6	—	3.8	32.0	12.3	255.9	27.4
1934–5	243.7	57.5	2.1	73.7	57.0	—	5.1	2.7	12.0	210.1	33.6
1935–6	238.3	57.5	2.3	77.7	30.5	10.0	5.7	0.2	8.6	192.5	45.8
1936–7	162.3	57.5	2.5	38.9	23.7	7.6	9.6	7.6	5.0	152.4	9.9
1937–8	191.6	57.5	2.5	65.3	23.5	9.4	3.0	0.4	20.3	181.9	9.7
Average (All years)	214.8	57.5	3.5	65.2	38.3	6.1	7.0	6.7	11.2	195.5	19.3

TABLE VIII.

Percentage Increase or Decrease in Expenses (Base 1929–30=100).

Year.	*Total Expenses.*	*Rent.*	*Rates.*	*Wages (Hired.)*	*Feeding-stuffs.*	*Seeds.*	*Imple-ments.*	*Sundries.*	*Total Direct Expenses.*	*Live-stock Bought.*
1929–30	% 100	% 100	% 100	% 100	% 100	% 100	% 100	% 100	% 100	% 100
1930–1	135	100	53	121	113	809	419	78	120	568
1931–2	115	100	28	119	102	1009	527	30	115	106
1932–3	101	100	21	108	100	1157	58	102	105	—
1933–4	157	100	21	135	215	328	2065	89	147	446
1934–5	135	100	21	130	171	443	173	86	121	547
1935–6	132	100	23	137	91	496	15	62	110	745
1936–7	90	100	25	69	71	833	490	36	88	161
1937–8	106	100	25	115	71	264	23	147	104	158

Rent, cost of labour, and expenditure on feedingstuffs, constitute the major part of farm expenses. There was no change in rent over the whole period but cost of hired labour showed a more or less continuous upward trend. In all years there was one hired man employed except in 1936-7 when employement only covered six months. The increase in the labour bill can therefore be mainly attributed to the higher rates of wages paid.

There does not appear to be any appreciable difference in the expenditure on feedingstuffs in the first four years—the amounts paid in these years varying from about £33 to £37. As a result of a reduction of the area under oats, a light hay crop and increased expenditure on pigs and poultry foods, the feedingstuffs bill in 1933-4 was very heavy and the cost rose to nearly £72, but in the following year was reduced to £57. Greater reliance on home-grown foods through the growing of more corn and some reduction in the number of pigs and poultry kept contributed to the curtailment of expenditure on bought foods in the last three years. As compared with 1929-30 the amount spent on feedingstuffs in 1936-7 and 1937-8 had been reduced by 29 per cent. Only in five out of the nine years were expenses incurred on fertilisers and the amounts paid varied from £7 11s 11d. to £14 14s. 0d. Purchases were mainly of phosphatic manures and included in all 15 tons Basic Slag, 2 tons Superphosphate, 4½ tons Compound manures, 5 cwts. Nitro Chalk and 1 cwt. Nitrate of Soda. Expenditure on seed was variable and ranged from £1 3s 0d. to £13 6s 0d.,—the higher costs being assocciated with heavy purchases of oats and hay seeds in the same year. Expenses on implements naturally vary according to the type of implement bought, and in some years expenses of this nature only included cost of small tools. Expenditure on implements, renewals, or small tools ranged from 4s. 9d. in 1935-6 to £32 0s 2d. in 1933-4, in which year a new mowing machine was bought. With regard to livestock purchases these varied from £6 3s 0d to £45 16s 2d. Except in 1930-1 when a heifer was bought, purchases of cattle were of young calves for rearing. Over the whole period 39 pigs (weaners) were bought and 23 of these were purchased between the years 1933-5. Up to 1932-3 there were no purchases of poultry but between 1933-5 about £20 was paid for day old chicks. In the following years only small sums, varying from 12s. to 33s., was accounted for in this way. As regards horses and sheep the only purchases recorded were in 1935-6 when £32 10s 0d was paid for a horse and £3 10s 0d for a ram.

Financial Results.

In all years there was a surplus of receipts over expenses. The worst year was 1933-4 when the cash balance was only £27 6s. The best year was in 1929-30 which showed a cash balance of £319 6s. While receipts had shown some recovery in 1933-4 the expenses in that year (owing to a greater outlay on new implements and higher expenditure on feedingstuffs) were the highest recorded over the whole period. A definite improvement in the cash balance is noticeable in 1934-5, and while there was some decline in the following year, the surplus of receipts over expenses as compared with that in 1935-6 had nearly doubled in 1936-7. This was followed by a slight fall in 1937-8 when the cash balance was about 38 per cent below that in 1929-30. Valuation differences showed depreciation of capital in five out of the nine years and in particular in 1931-2 and 1932-3.

The profits as represented by farm income dropped by 92 per cent between 1929-30 and 1932-3. Judged on this basis the best year experienced by this farmer in the whole period was 1929-30 when the farm income was £297.4 and the worst year was in 1932-3 when the farm income was only £23.1 The receipts in these particular years for three of the products upon which the farmer mainly depended for the greater part of his income were as follows :—

	1929-30.			1932-3.		
	£	s.	d.	£	s.	d.
Cattle	150	15	0	90	2	6
Butter	112	19	2	37	5	9
Sheep and Wool	117	0	10	57	13	0

The same number of sheep were sold in both years but there were some slight differences in the proportions of lambs and breeding ewes. In 1929-30 the farmer received 31s 7d. per head for his lambs and 34s. 5d. for the ewes. In 1932-3 the lambs averaged 13s 5d. and the ewes 16s 6d. per head. In the case of cattle, numbers sold and prices realised affected returns. In 1929-30 14 cattle were sold at an average price of £10 15s 4d. each, as against 9 in 1932-3 at £10 0s 5d. per head. The production of butter was very low in 1932-3 and this together with some reduction in price was responsible for the small returns.

Conditions began to improve in 1933-4 and continued to do so up to 1935-6. In the two following years there was a decided improvement in the financial position but even so the farm income in 1937-8 was still 28 per cent below that in 1929-30. The results for that year indicate that the returns to the farmer were equal to about £5 14s 0d per week. Other years showed a variation of from 9s. to £4 2s 6d per week and over the whole period the returns to the farmer averaged £3 1s 2d per week. (See Table IX).

TABLE IX.

Receipts, Expenses, Valuation Differences, and Farm Income.

Year.	*Receipts* (*a*).	*Expenses* (*b*).	*Surplus.*	*Valuation Difference.*	*Farm Income* (*c*).
	£	£	£	£	£
1929-30	500.0	180.4	319.6	—22.2	297.4
1930-1	436.1	243.6	192.5	+41.0	233.5
1931-2	362.9	207.2	155.7	—40.6	115.1
1932-3	276.0	182.9	93.1	—70.0	23.1
1933-4	310.9	283.3	27.6	+64.1	91.7
1934-5	370.5	243.7	126.8	— 3.0	123.8
1935-6	354.7	238.3	116.4	+12.4	128.8
1936-7	380.9	162.3	218.6	—14.9	203.7
1937-8	391.5	191.6	199.9	+14.7	214.6
Average (All years)	375.9	214.8	161.1	— 2.0	159.1

(*a*) Receipts include value of the farm produce consumed in the house plus rent of farm house at rateable value.

(*b*) No charge is made in the expenses for the farmers' own time as worker or manager or any manual work done by his wife.

(*c*) Farm income represents the difference between receipts and expenses plus or minus valuation differences.

It has already been stated that the farmer was fully employed in manual labour and that the wife devoted one-third of her time to farm work. If the wages of the occupier were assessed at 35s. per week and the wife at 22s. per week (which would be about the normal rate of wages they would earn as hired workers) the total wages in respect of their labour would amount to £111. per annum. Again some allowance must be made for the use of the capital invested in the farm and a fair rate of interest would be 4 per cent per annum. The results may now be further considered after allowing wages to the occupier and his wife for their labour and interest on the capital invested. (See Table X).

In five out of the nine years (1931-6) the farm income failed to meet these charges. The situation varied and was least satisfactory in 1932-3 and 1933-4 when there was a deficit of £111 and £42.2 respectively. There was a surplus of £161.5 in 1929-30 and £97.2 in 1930-1 and again in 1936-7 and 1937-8 but the surpluses in the

TABLE X.

Farm Returns after allowing Wages to Occupier and Wife and interest on Farm Capital.

Year.	*Farm Income.*	*Allowance for Wages for Farmer and Wife.*	*Allowance for interest at 4% on Farm Capital.*	*Amount by which Farm Income was less than (—) or exceeded (+) a fair return for Capital and Farmers' and Wife's Labour.*
	£	£	£	£
1929-30	297.4	111.0	24.9	+161.5
1930-1	233.5	111.0	25.3	+ 97.2
1931-2	115.1	111.0	25.3	— 21.2
1932-3	23.1	111.0	23.1	—111.0
1933-4	91.7	111.0	22.9	— 42.2
1934-5	123.8	111.0	24.1	— 11.3
1935-6	128.8	111.0	24.3	— 6.5
1936-7	203.7	111.0	24.2	+ 68.5
1937-8	214.6	111.0	24.2	+ 79.4
Average (All years)	159.1	111.0	24.3	+ 23.8

last two years were much smaller. Over the whole period the farm income was sufficient to cover the wages of the occupier and his wife and to allow interest on farm capital at the rates already stated and to leave an average surplus of £23.8. per annum.

CO-OPERATIVE MARKETING OF FARM PRODUCTS IN WALES.

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Co-operative societies in Wales either exclusively or partly engaged in the marketing of farm products are fewer in number than those which deal in agricultural requirements. This is mainly due to the fact that other forms of business entered the field and became firmly established before the co-operative movement became active. Joint stock companies and private businesses have undertaken the marketing of many farm products, and in many cases it would probably be unwise for co-operative societies to attempt to start in competition with them. And in many instances these businesses are far better supplied with capital than the co-operative societies and in consequence can withstand competition remarkably well.

TABLE I.

Turnover of Marketing Societies.

Year.	*Dairy Produce.*	*Eggs and Poultry.*	*Other.*	*Total.*
	£	£	£	£
1935	81,632	26,342	9,316	117,290
1936	114,225	19,150	1,561	134,936
1937	151,329	18,992	7,514	177,835

As can be seen from Table I a considerable rise has recently occurred in the total turnover of farm products handled by co-operative societies. The quantity of dairy products sold has advanced sharply which is due mainly to the establishment of new societies in recent years.

Dairy Societies.

Since the advent of the Milk Marketing Scheme the quantity of milk sold off farms in Wales has shown a considerable rise. In fact, during the last four years the total quantity has risen from 38 million gallons to 63 million gallons, a rise of 66 per cent. Farmers have been anxious to avail themselves of the comparatively good market for milk, and in some cases the production of other products has fallen owing to specialisation in milk production. The output of milk in the Principality, in fact, has risen at a faster rate than could be absorbed by the local liquid market.

In the same period the quantity of milk used for manufacturing purposes in Wales has risen from 12 million gallons to 23 million gallons, a rise of 91 per cent. This has called for an appreciable increase in manufacturing facilities; existing factories have been taking larger quantities and in some areas new depots have been established. In some districts, but more particularly in the rather inaccessible regions, butter and cheese are still made on the holdings. Farmers in such areas are, in general, somewhat anxious to dispose of their milk supplies in liquid form. And there may be still room in such places for the establishment of co-operative dairies. Such a movement need not disturb existing systems of livestock rearing, as it may be desirable to preserve them, and it is also necessary in many cases to improve the technique of manufacturing dairy produce. Some of the dairy products made on farms in Wales have difficulty in finding a remunerative market. This is largely due to their varied character, quality and composition. Such produce is at a disadvantage in the market compared with the graded and standardised articles made in factories and with those obtained from abroad.

Wales is a country of mixed husbandry and small farms, and the output per holding of any particular product is comparatively low. In view of great variations in fertility of soil, quality of herbage and similar factors, the produce is often very varied in character. Under such conditions the need of an efficient marketing system is considerably greater than in countries where each holding regularly produces a large quantity of uniform commodities. To-day milk amounts to about 30 per cent of the total output of farms in Wales and exceeds in importance that of any other single product.

TABLE II.

Average Daily Gallonage of Milk per Supplier received by a Dairy.

Month.	*1934*	*1935*	*1936*	*1937*
January	6	8	9	8
February	7	9	11	8
March	9	11	12	9
April	10	13	13	10
May	13	17	16	13
June	13	18	17	14
July	13	17	15	13
August	13	15	14	12
September	13	13	12	11
October	11	11	10	8
November	9	9	8	7
December	7	9	7	6
Average	10	12	12	10

Yet the average daily supply per farm is low and shows comparatively wide seasonal variation. In many regions winter production of milk and dairy produce is negligible, nearly the whole of the output is obtained in the summer months. Under such conditions the problem of marketing is often extremely difficult (see Table II).

Under present conditions it is doubtful whether any efficient marketing plan for farm manufactured produce, which included provision for grading and standardisation, would be feasible. It is probable that the only practicable method is to introduce uniformity at the point of manufacture. This involves the discontinuance of farm manufacture of dairy produce and the transfer of the milk to creameries. Co-operative societies might be established in some regions for this purpose and this would be very beneficial to many small farmers, as it would greatly increase the marketability of the produce. Financial returns to milk producers in regions which do not normally supply the liquid market have greatly improved since the advent of the Milk Marketing Scheme. Under the pooling system there is a considerable difference between the prices received by producers and those paid by factories for the milk used for making butter.

TABLE III.

Factory Manufacture of Butter.

Year.	*Milk used per lb. Butter.*	*Factory Costs of Manufacturing Butter.*	*Price Paid for milk by Butter Factory.*	*Average price received by Suppliers.*
	Gallons.	*Pence per lb.*	*Pence per Gallon.*	*Pence per Gallon.*
1934	2.51	1.61	3.69	9.04
1935	2.41	1.25	3.98	9.38
1936	2.54	1.22	4.06	8.89
1937	2.64	1.65	4.53	9.77

Farmers supplying the factory on which the figures in Table III are based received an average net price of slightly over nine pence a gallon for their milk during this period, and they were relieved of the work of manufacturing and marketing their butter. Apart from the direct financial gain, however, it is found that the transfer of the manufacturing of dairy products from farm to factory is a step in the right direction. The ultimate product shows greater uniformity and in consequence there is less difficulty in finding a market.

At one time considerable amounts of cheese were made on Welsh farms, but now this industry has almost disappeared. There are only a few co-operative dairy factories in Wales which produce cheese, the majority specialise in the production of butter, cream and the sale of liquid milk. Some societies have facilities for the manufacture of both cheese and butter and are therefore concerned with the relative merits of the two enterprises. The figures in Table IV are based on the study of a business where both enterprises are adopted. Although prices of both articles were comparatively low during the period, cheese prices have recovered to a greater extent from the low level prevailing in 1936.

There are many factors to be considered, however, apart from the relative market prices of the two commodities. It generally happens, unless proper facilities are available, that greater difficulty is experienced in dealing with by-products of cheese manufacture. Trouble regarding pollution of streams is less likely to happen at butter factories and it is generally much more difficult to sell whey than skim milk, and frequently impossible to realise the value of the whey by direct sale. It may be necessary to make special provision for its disposal.

Again, a factory may have built up a certain amount of goodwill in the market for one product and the produce may command a special price. Years may elapse before such goodwill is established and during the initial period the produce may have to be sold at a rather low price in order to make trade connections. Certain societies have built up a good local trade in butter, but it is doubtful whether one could be established so easily for cheese.

TABLE IV.

Cheese and Butter Enterprises 1936-7.

	Cheese Enterprise Per cwt.		*Butter Enterprise Per cwt.*	
	s. d.	*s. d.*	*s. d.*	*s. d.*
Cost of Milk		42.10		82. 7
Manufacturing Costs :				
Wages and Insurance	3.10		4. 9	
Light and Power	1. 1		1. 0	
Rent, Rates and Office	0. 2		0. 2	
Chemicals and Materials	1. 1		1. 3	
Marketing Expenses	1. 0		0.10	
Miscellaneous	1. 7		1. 7	
Depreciation	0. 6		0. 6	
Total Cost	9. 3	9. 3	10. 1	10. 1
Total Outlay		52. 1		92. 8
Receipts from Cheese and by-products		59. 8		—
Receipts from Butter and by-products		—		103. 2
Profit		7. 7		10. 6

The cheese made at this factory was mainly of the Cheshire variety and both the butter and cheese were sold on the wholesale market. During the period of this enquiry the cheese enterprise was proving more profitable than butter production when both are considered on the basis of the milk utilised. Although the profit per cwt. of butter was higher than that of cheese, the profit per gallon of milk used was lower. This is the problem which faces factory managers who have facilities for dealing with both commodities. But the most important factor to be considered in determining the more profitable enterprise is the relative prices obtainable for the two commodities. The significance of changes in their prices, however, varies in accordance with the difference in the quantities of milk needed to produce a cwt. of either product. Changes in the price of cheese are reflected to a greater extent in the profitability of the enterprise than are movements in the price of butter. In fact, changes in the price per cwt. of butter need to be about twice as great as those of cheese in order that the profitability of the two enterprises may be affected to the same extent.

Eggs and Poultry.

On the whole the marketing of eggs and poultry through agricultural co-operative societies has suffered a set back. This has been largely due to the uncertainty regarding the future line of development which the marketing of these products will take. At one time a statutory marketing scheme was contemplated, and in consequence the establishment of co-operative societies was delayed. There is certainly need for reforming the methods of marketing eggs and poultry in many parts of the Principality. The bulk of the business is now in the hands of dealers, provision merchants and others who only pursue it as a part-time occupation. A good deal of the supply is also sold at the produce markets which are scattered throughout the country. In general the work is very improperly done; there is no satisfactory system of grading and standardisation and prices show considerable variation within comparatively small areas. The chaotic methods of marketing at present in vogue are exercising a very harmful influence on the output of eggs; producers are seldom paid on the basis of quality and are not sufficiently encouraged to improve their methods of production. The problem of marketing in this field is one of establishing additional depots where the eggs can be properly candled, graded and sold under the " National Mark " (see Table V).

Produce Associations.

A large proportion of the dairy and garden produce sold in

TABLE V.

Produce Sales by Requisite Societies.

Year	*1935*	*1936*	*1937*	*1935*	*1936*	*1937*
	£	£	£	%	%	%
Dairy Produce	3,704	2,662	1,635	12.3	12.3	7.9
Eggs & Poultry	25,258	17,885	17,217	83.7	82.3	82.7
Grain, etc.	82	69	109	0.3	0.3	0.5
Wool	1.119	1,119	1,861	3.7	5.1	8.9
Total	30,163	21,735	20,822	100.0	100.0	100.0

Wales is obtained from comparatively small producers. Allotment holders, gardeners and others often have appreciable quantities of a variety of products to sell, but frequently experience difficulty in finding a suitable market. Such persons mainly produce the commodities for home consumption, but at certain periods of the year there must be a considerable supply available for sale. Owing to lack of marketing facilities much of the produce may be wasted, although in many urban centres there may be an ample market for it. It is doubtful, however, whether the establishment of permanent organisations to cope with this intermittent flow would be justified. Special facilities are probably needed to cater for such part-time producers and the cost of marketing the produce needs to be kept at a very low figure.

TABLE VI.

Progress of a Produce Association.

		1934	*1936*	*1938*
Membership		48	40	68
		£	£	£
Captial		6	23	24
Sales :	Dairy Produce	187	205	135
	Garden ,, ...	190	240	301
	Eggs and Poultry	1,094	1,270	1,230
	Other	102	128	303
	Total	1,573	1,843	1,969

The actual work of marketing is undertaken by members of Women's Institutes and others interested in the work. The markets themselves should be registered under the Industrial and Provident Societies Acts ; this ensures that they are run on democratic lines with limited liability. There is considerable room for further development of this form of organisation in Wales. Women's

Institutes have been established in many districts and in many of these there is need of improving marketing facilities for small producers. An ample opportunity is afforded for voluntary work which, of course, is one of the principles on which the co-operative movement is built. The sale of produce in this way often serves to introduce members to improved methods of preparing and presenting produce for sale. Inferior consignments are rejected and care is taken to grade and standardise commodities before they are offered for sale and a uniform price is established for comparable articles. These marketing agencies therefore serve to make contacts between buyers and sellers; they go a long way to guarantee the quality of the goods sold and are also a means of teaching suppliers some of the business principles that must be observed in successful marketing (see Table VI).

Livestock Marts.

During recent years, especially since the passing of the Livestock Industry Act, 1937, efforts have been made to improve the livestock markets of the country. A livestock mart, however, if well managed, can be run very effectively on co-operative lines. And it may be possible to re-organise some of the co-operative marts in the Principality so that they can function in a more satisfactory manner. Unfortunately, very little progress has been shown during the last few years, both the membership and the capital investment have remained comparatively stationary since 1930.

There is considerable variation in the methods of control exercised by the various societies. In some cases an auctioneer is employed and the income of the society is obtained from part of the commission charged for selling. In other cases the auctioneers are charged a fixed annual rental for the use of the premises; the cost of the equipment being borne by the society. As a result of this arrangement the societies are not responsible for the development of the market centres which they own. This is largely in the hands of the auctioneers concerned. Most of the centres at which the marts are situated are well suited for development and the problem of providing up-to-date facilities for the reception and handling of stock needs investigation. With the development of the policy of centralising markets there may be danger that obsolete and badly equipped centres may be closed and the stock moved elsewhere. Societies must therefore adopt a progressive and expansive policy if they are to survive; they have made but little progress in recent years although during this period many other marketing centres have made great strides (see Table VII).

TABLE VII.

Co-operative Marts.

	No. of Members or Shareholders.		*Share Capital.*	
	1930	*1937*	*1930*	*1937*
			£	£
Talybont (Cards.)	81	80	91	93
Talybont (Brecon)	184	184	1,723	1,723
Kidwelly (Carms.)	172	158	301	299
Devil's Bridge (Cards.)	124	124	440	440
Nelson and District (Glam)	38	37	1.075	1,075

The work of marketing livestock on co-operative lines, however, has made considerable progress in another way. During the last four years an increasing number of animals has been dispatched to certain abattoirs for sale on the grade and dead weight basis. The problem of marketing fat stock in Wales presents much the same problems as those that arise in the case of other commodities ; as the supply offered by individual producers is comparatively small, the bulking of different lots is generally necessary before dispatch to distant markets.

TABLE VIII.

Stock Consigned from Wales.

Year.	*Fat Cattle.*	*Sheep and Lambs.*	*Pigs.*
	No.	*No.*	*No.*
1934	950	8,483	—
1935	1,350	13,000	200
1936	1,180	16,351	325
1937	622	14.006	104

Many farmers in Wales were not conversant with the Scheme at first, consequently marketing committees were set up in various districts ; these served to familiarise producers with the plan and to encourage them to avail themselves of the opportunity offered. Local agents were appointed whose duty it was to arrange for supplies of stock from different farms and to see that suitable animals were assembled with a view to the consignment of uniform truck loads. The Railway Companies assisted by offering favourable terms for carriage. This was of considerable assistance to small suppliers as they could not profitably send their stock individually owing to the high rail charges that would be entailed (see Table VIII).

Although the number of stock handled in this way has not been very large, the Scheme has had an appreciable effect on the prices received by farmers. On the whole they have been satisfied with the returns as prices have generally been higher than those prevailing locally. In some areas a slight increase in offerings of stock causes an undue fall in prices as markets are quickly saturated. Under such conditions producers do not always obtain the full value for their animals and the operation of buyers' " rings " often restricts free competition. The movement of livestock to distant markets has often relieved congestion in Welsh markets and in consequence local prices have improved.

The marketing of store-cattle has also been tackled on co-operative lines. A body was recently formed, viz., the Welsh Dragon Mark Association for the purpose of developing this work. All cattle marketed under this plan, being the progeny of tuberculin-tested sires, are ear-marked, buyers therefore are assured that the stock is of high quality. Large sales of such cattle are held periodically and wide publicity is given to the Scheme. Buyers are assured that large supplies of uniform lots are available and as a result far more satisfactory markets for such cattle are established under this co-operative plan than would otherwise be the case.

SOME FURTHER STUDIES OF HOUSEHOLD BUDGETS IN THE RHONDDA VALLEY.

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The chief results of a household budget survey conducted by the Department* in part of the Rhondda Valley during July 1936, were published in a previous issue of this Journal.** It was then stated that the conclusions reached on the relations between food and non-food expenditure and between individual commodities within these groups to total income were merely tentative owing to various reasons. In the first place, during this period some households spent more than they received while others saved appreciable amounts, and secondly, the study could not bring out any seasonal variations in family expenditure which may exist. It was further stated that in order that these relationships may be more accurately determined it was necessary that the budgets should be collected over a much longer period. In order that this

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purpose may be achieved contact with certain of the co-operating households was maintained, and an attempt was made to eliminate the discrepancies between income and expenditure which may be due to the short length of period to which the data referred by the publication of complete statements of income and expenditure for eight households for twelve months.* The present study deals with the second of these limiting factors and is therefore primarily concerned with the seasonal variations in household expenditure.

In this survey it is intended to compare a set of winter budgets with those relating to July 1936 mentioned above. This latter study was based on 46 households. The winter budgets represent the incomes and expenditures of 35 of these same households for the months of January, February, or March, 1937, although most of them are for January. The average size of household for the whole group in the winter study was 4.45 persons as compared with 4.50 for the summer study, while the average income per person per month was £2 14s 7d and £2 14s 2d. respectively. It appears therefore that taken together the winter budgets are quite a representative sample of the larger group.

The proportions of income obtained from different sources were also very similar. In both the summer and winter studies somewhat over 60 per cent were obtained from wages and salaries, just under one-third from Unemployment Insurance and Public Assistance, and the remainder from pensions and other sources. It is seen therefore that over the whole group there was considerable reliance on social income. In those households where the head was in employment about 96 per cent of income was obtained from wages and salaries in both periods. The proportions of income received from the different sources in the two classes of unemployed households, namely, those with and without supplementary earners respectively, were very similar, except for a somewhat heavier dependence on Unemployment Insurance and Public Assistance in the latter type in the winter period, the actual proportions being 79.6 and 95.9 per cent respectively.

These budgetary studies have been conducted with a view to studying the food habits of urban households on different income planes, and in order to do this it is necessary to bear in mind the relation between food and non-food expenditure. The summer study contained an itemised statement of the proportions of total expenditure accounted for by these non-food requirements for the group as a whole and for different types of households within the group. For purposes of comparison these have been set out alongside the corresponding proportions for the winter period in Table I.

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* *Ibid*, Vol. 14, pp. 91-103.

It may be stated moreover that the following account is concerned, *not so much with differences in the amounts and proportions* of expenditure in households of different types or of varying economic status, as with a comparison between these amounts and proportions at the two seasons.

TABLE I.

Proportion of Expenditure on All Items.

Particulars.	*Head Unemployed without supplementary earners.*		*Head Unemployed with supplementary earners.*		*Head Employed.*		*Whole Group.*	
	Summer. %	*Winter* %	*Summer* %	*Winter* %	*Summer* %	*Winter* %	*Summer* %	*Winter* %
Food	49.2	47.1	47.8	47.7	42.1	39.6	45.4	43.1
Rent and Rates	17.8	20.2	14.0	15.2	14.3	13.2	15.7	15.6
Fuel and Lighting	7.8	11.2	5.3	8.9	7.4	9.0	7.1	9.6
Clothing	7.5	3.3	13.2	3.9	10.1	17.2	9.9	11.0
Insurance	5.1	4.2	5.3	3.7	3.5	5.2	4.4	4.7
Personal	3.5	3.3	3.7	6.3	6.7	2.9	5.8	3.6
Soap and Laundry	2.2	2.8	1.6	2.8	2.3	1.9	2.1	2.3
Thrift Clubs	1.8	4.0	1.7	7.7	1.6	4.2	1.7	4.7
Books, Library, Subs.	1.3	1.2	1.7	1.7	1.7	1.3	1.6	1.3
Medical and Chemist	1.3	1.3	1.6	0.7	3.0	1.3	2.1	1.2
Other	2.5	1.4	4.1	1.4	7.3	4.2	4.2	2.9
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

It will be observed that the proportionate expenditures on food showed some variations in the different types of households. That for the unemployed group with no supplementary earners showed a slight reduction in the winter period, that for the unemployed group with supplementary earners showed no change, while the proportion for the households with the heads in employment was slightly lower. But some probable reasons for these movements will be given later. Over the whole group, however, it may be said that the proportionate expenditure on foodstuffs at these two periods showed practically no change.

As regards the non-food expenditure the only item which exhibited a marked seasonal character in all household types was fuel and lighting, and the unemployed groups showed rather greater proportionate increases in the winter than did the employed households. The proportions accounted for by rent and rates were also somewhat higher in winter in the unemployed households. Expenditure on clothing appeared to be spasmodic, while the indications are that payments into thrift clubs are heavier during winter. With the exception of "personal" expenditure and insurance, the proportions of income spent on the remaining items were low and showed little variation.

In Table II the averages of food expenditure per person per month are set out.

Over the whole group, size of households and incomes were almost identical in the two periods, and the total food expenditure showed practically no change. Neither were there any perceptible variations in expenditures on the different kinds of foodstuffs. Some of the household types do, however, show some changes in food expenditures in summer and winter respectively, but it would appear that these were due not so much to seasonal variations in their food habits as to differences in purchasing power at these two periods.

Thus in the unemployed households with no supplementary earners the average size of household was somewhat larger in the winter period, and the average income per person showed a reduction of about 13 per cent. It was natural, therefore, that there should be less spent on food during this second period, and that the make-up of the dietaries should be rather different. The principal change was a considerably reduced expenditure on meatstuffs, and a slightly greater dependence on breadstuffs. Expenditure on butter and cheese, vegetables and preserves also showed quite appreciable reductions, while purchases of the remaining items were also slightly lower than those recorded in the summer.

The differences in the food expenditures of those households

TABLE II.

Expenditure on Foodstuffs per Person per Month.

Type.	*Head Unemployed without supplementary earners.*		*Head Unemployed with supplementary earners.*		*Head Employed.*		*Whole Group*	
	Summer.	*Winter.*	*Summer.*	*Winter.*	*Summer.*	*Winter.*	*Summer.*	*Winter.*
Number of Households	21	15	8	5	17	15	46	35
Number of Persons	90	73	45	27	72	56	207	156
Average Income per Person	£1 16 6	£1 11 10	£2 11 9	£2 11 7	£3 17 9	£4 5 7	£2 14 2	£2 14 7
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Meats, Suet, Fish, Eggs	5 0½	3 5½	6 1¾	6 6½	7 10¾	9 2½	6 3	6 0¾
Cereals and Breakfast Foods	2 11	3 1¾	4 9	4 5	3 8¾	4 7¼	3 7	3 10½
Butter, Margarine and Cheese	3 4½	2 8½	4 6½	4 0¼	4 4½	4 3¾	3 11½	3 6
Milkstuffs	1 4¾	1 4	1 4	1 0	2 6	2 10½	1 9¼	1 10
Fruit	0 7¾	0 6	0 9¼	1 4¾	1 11¼	2 3	1 1¾	1 3½
Vegetables	1 8¾	1 3	1 7	1 4	2 2¾	2 4	1 10½	1 8
Preserves	1 3¼	1 0¾	1 10½	1 11¾	2 1½	2 6½	1 8½	1 9
Beverages	1 0	0 11½	1 5½	1 8¼	1 6½	1 8¼	1 3½	1 4
Home-produced food and meals from home	0 1	—	1 0	—	0 2¾	—	0 4¼	—
TOTAL	0 17 5½	0 14 5	1 3 5½	1 2 4½	1 6 6¾	1 9 9¾	1 1 11¼	1 1 3¾

where the head was in employment may also be ascribed to differences in purchasing power at the two periods. In this case the economic status of the households in the winter sample had improved considerably, and this was reflected in the dietaries.

But the unemployed sub-group with supplementary earners enables a safe comparison to be made, as average size of households and incomes per person may be regarded as identical. And as in the case of the whole group, no very striking differences were brought out. Expenditures on cereals and breakfast foods and on butter and cheese were rather lower in the winter period and that on meatstuffs higher, but over the whole group there was a tendency for these variations to be evened out.

On the whole, therefore, it may be said that in the form in which they have been set out in Table II, there does not seem to be any appreciable variation in summer and winter dietaries. This was also found to be the case with the yearly budgets which were published in the previous issue of this Journal. It is not known whether any other budget studies have been made which enable such a comparison to be made. But consumption of different kinds of meats appears to show marked seasonality. In a survey* published in 1931, it was found that the consumption of beef and pork was lower, and that of mutton and lamb higher during the summer as compared with the winter. These seasonal variations, however, had a counter-balancing effect so that the total meat consumption showed little change between summer and winter.

In Table III the expenditures considered above are set out in the form of proportions.

Of the more important foodstuffs the proportionate expenditure on meatstuffs for the whole group was practically identical during the two periods, that on cereals and breakfast foods was slightly higher during the winter, and that on butter and cheese rather lower. Contrary to general expectations the proportionate expenditure on fruit was higher in winter in all groups with the exception of the unemployed households without supplementary earners, but this was chiefly due to increased consumption of the canned and dried variety.

The summer study contained a tabular statement of food expenditure by income groups, and for purposes of comparison these, in slightly modified form, have been set out alongside the corresponding figures for the winter period (see Table IV).

It will be observed that the averages for all households have not been given as the actual expenditures and proportions for these have already been given and commented on in Tables II and III respectively. But here again the same difficulty is encountered in comparing the summer and winter expenditures. The income groupings are sufficiently wide to admit of considerable differences

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*Arthur Jones & S. M. Makings—Some Aspects of Meat Distribution and Consumption.

TABLE III.

Proportion of Expenditure on different kinds of Foodstuffs.

Type.	*Head Unemployed without supplementary earners.*		*Head Unemployed with supplementary earners.*		*Head in Employment.*		*Whole Group.*	
	Summer.	*Winter.*	*Summer.*	*Winter.*	*Summer.*	*Winter.*	*Summer.*	*Winter.*
Average Size of Household	4.28	4.86	5.62	5.40	4.23	3.73	4.50	4.45
	%	%	%	%	%	%	%	%
Meats, Suet, Fish, Eggs	28.9	24.0	26.2	29.2	29.7	30.9	28.5	28.4
Cereals and Breakfast Foods	16.7	21.8	20.2	19.8	14.0	15.5	16.3	18.2
Butter, Margarine and Cheese	19.3	18.8	19.4	18.0	16.5	14.5	18.1	16.4
Milkstuffs	8.0	9.2	5.7	4.5	9.4	9.7	8.1	8.6
Fruit	3.7	3.5	3.3	6.2	7.3	7.5	5.2	6.1
Vegetables	9.9	8.7	6.7	6.0	8.4	7.8	8.5	7.8
Preserves	7.3	7.4	8.0	8.8	8.0	8.5	7.8	8.2
Beverages	5.7	6.6	6.2	7.5	5.8	5.6	5.9	6.3
Home-produced food and meals from home	0.5	—	4.3	—	0.9	—	1.6	—
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TABLE IV.

Expenditure on Foodstuffs per Person per Month by Income Groups.

	Summer.	*Winter.*	*Summer.*	*Winter.*	*Summer.*	*Winter.*	*Summer.*	*Winter.*
Number of Households	16	15	15	6	5	6	10	8
Number of Persons	85	82	64	27	20	18	38	29
Average Income per Person	£1 11 0	£1 8 8	£2 7 6	£2 11 4	£3 7 8	£3 8 11	£5 10 2	£5 19 1
Income Range	£1 and under £2.		£2 and under £3.		£3 and under £4.		£4 and over.	
	£ s. d.	£ s. d.	£ s. d’	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Meats, Suet, Fish and Eggs	4 2	3 3	5 11	4 11¼	8 7¼	7 10	10 4	13 11½
Cereals and Breakfast Foods	2 10	3 1	3 10	4 11	3 7½	4 0½	4 10½	5 1
Butter, Margarine and Cheese	3 5½	2 7½	3 6½	3 2½	4 1¾	4 6½	5 10	5 7¾
Milkstuffs	1 1½	1 1¾	1 8¼	1 11¾	2 4	2 1¾	2 11¾	3 4¾
Fruit	0 4¾	0 5¾	0 9¾	1 6¾	2 5¾	1 8	2 6½	2 11¼
Vegetables	1 6¼	1 3	1 8½	1 9½	2 6	2 1½	2 6¾	2 6¼
Preserves	1 2½	1 1	1 9¾	2 5¾	1 6¾	1 11	2 8	2 10½
Beverages	0 11¼	0 10½	1 3	1 7¼	1 6	1 8¼	2 1¼	2 2
Home produced food and meals from home	0 2¾	—	0 9¼	—	—	—	0 0¾	—
TOTAL	0 15 10½	0 13 9½	1 1 4	1 2 5¾	1 6 9	1 5 11½	1 13 11½	1 18 7

in purchasing power, and unfortunately such variations do occur between the summer and winter groups. The samples are, moreover, for a small number of households. Such differences in food expenditures as exist may, perhaps, be almost wholly accounted for by the differences in the economic status of the groups at the two periods. It is not possible therefore to make any categorical statement on the variations in summer and winter expenditures by income groups.

The households with *per capita* incomes ranging from £2 to £3, however, even after allowing for differences in purchasing power, showed some striking changes in diets at the two periods. Of these, the decreased consumption of meatstuffs, and of butter, margarine, and cheese during the winter, and the increased purchases of cereals and breakfast foods may be mentioned. Expenditure on fruits was almost twice as great in the winter, while that on the remaining items also showed increases. But a great deal of the fruit and vegetables consumed by this group in the summer were obtained from their own allotment gardens.

Some additional analysis has been made on the winter budgets, and this is presented in summarised form in Table V.

The characteristic features of the diets of households in different income groups, and also the differences between the living standards of households suffering from varying degrees of unemployment and those where the head was in employment have already been studied. It was found, moreover, that the differences between the standards of living of the unemployed and employed groups were very marked, that of the former being deplorably low. But hitherto only the average position of the unemployed households grouped broadly according to whether or not they contained supplementary earners has been given. It was found that those unemployed households which contained one or more of these, were, on the average, considerably better off than those without. Households within the " unemployed " group therefore suffer from varying degrees of poverty. Owing to the widespread nature of unemployment it is of vital importance from the standpoint of the health of the growing generation to enquire whether the unemployed households which contain children are the greater or lesser sufferers.

The twenty unemployed households have therefore been classified according to whether or not they contain children, while these two groups have been further sub-divided according to whether or not they contain supplementary earners.

It will be seen from Table V that the households with children were somewhat larger than those without, while the average income per person of the former was £1 7s. 10d. lower, and expenditure on

TABLE V.

Expenditure on Foodstuffs per Person per Month by Unemployed Households.

	With Children.				*Without Children.*			
	Without Supplementary earners.	*With Supplementary earners.*	*Total of all Households with children.*		*Without Supplementary earners.*	*With Supplementary earners.*	*Total of all Households without children.*	
Number of Households	11	2	13		4	3	7	
Number of Persons	59	14	73		14	13	27	
Average Size of Households	5.36	7.00	5.61		3.50	4.33	3.86	
Income per Person per Month	£1 9 6	£1 10 3	£1 9 8		£2 1 8	£3 14 7	£2 17 6	
	£ s. d.	£ s. d.	£ s. d.	%	£ s. d.	£ s. d.	£ s. d.	%
Meats, Suet, Fish and Eggs	3 2¾	3 2¼	3 2½	23.4	4 5¾	10 1¾	7 2½	29.6
Cereals and Breakfast Foods	2 10¾	3 1½	2 11¼	21.5	4 2½	5 9¾	4 11¾	20.5
Butter, Margarine and Cheese	2 7¾	2 8½	2 7¾	19.3	3 0½	5 5¼	4 2¼	17.2
Milkstuffs	1 2¾	0 8½	1 1½	8.2	1 9	1 3¾	1 6½	6.3
Fruit	0 5¼	0 9½	0 6	3.7	0 8½	2 0½	1 4¼	5.6
Vegetables	1 3	1 6¾	1 3¾	9.6	1 3½	1 1	1 2¼	4.9
Preserves	1 0	1 4¾	1 1	7.9	1 3½	2 7½	1 11¼	8.0
Beverages	0 10½	0 9	0 10½	6.4	1 2¼	2 8¼	1 11	7.9
TOTAL	£0 13 6¾	£0 14 2¾	£0 13 8¼	100.0	£0 17 11½	£1 11 1¾	£1 4 3¾	100.0

foodstuffs was about 10s. 7d. lower. No scale of family coefficients has been used to evaluate children and females in terms of adult males, but even allowing for the lesser requirements of children for certain forms of foodstuffs, it is, to say the least, very unfortunate for the future welfare of society that the households which contain children should be the worst victims of unemployment.

Of the households with children, those without supplementary earners were the smaller numerically, while their income per person and food expenditure was slightly lower than those with supplementary earners. Expenditures on meatstuffs, cereals and breakfast foods, and on butter and cheese, were very much the same in both, that on milkstuffs was heavier in the households without supplementary earners, while the lower expenditure of this group was accounted for by reductions in the fruits, vegetables and preserves.

The households without children were, taken together, considerably better off than those with children. There was, however, a considerable difference between the economic status of the households in the former group depending on whether or not they contained supplementary earners. The average size of household was somewhat smaller in the sub-group without supplementary earners, but the income of those with such earners was naturally higher. It so happened that the three households in the former group had between them six supplementary earners, some of whom were in receipt of incomes rather above the average.

The chief differences between the food expenditures of some of these types of households during the winter period are given in Table VI.

In conclusion it may be useful to summarise the chief results yielded by this survey. As regards non-food requirements, the only item which showed marked seasonality in purchases was fuel and lighting, expenditure by all types of households naturally being heavier in winter. Total outlay on food by all households taken together was practically the same for the two seasons, neither was there much variation in purchases of different classes of foodstuffs. It has not been possible to make accurate comparisons of seasonal changes for households in different income groups, although there do not seem to be reasons for supposing that such variations exist. Information obtained from a number of unemployed and employed households for a period of twelve months showed little variation in food expenditure between summer and winter.

A study of the nature of food habits and standards of living of households on different income and social planes has already been made on the basis of the data obtained in July, 1936, so that there is no need to recapitulate these general observations. In classifying the unemployed households in the winter study, however, according to whether or not they contained children, it was found that the incidence of unemployment was much heavier in the former and a statement giving the actual position has been incorporated in the text.

TABLE VI.

Expenditure per Head on Foodstuffs.

	Unemployed with children without supplementary earners.		*All Unemployed Households.*		*Employed Households.*	
	s d.	%	s. d.	%	s. d.	%
Meats, Suet, Fish and Eggs	3 2¾	23.8	4 3½	25.9	9 2½	30.9
Cereals and Breakfast Foods	2 10¾	21.4	3 5¾	21.0	4 7¼	15.5
Butter, Margarine and Cheese	2 7¾	19.5	3 0¾	18.5	4 3¾	14.5
Milkstuffs	1 2¾	9.1	1 2¾	7.5	2 10¾	9.7
Fruit	0 5¼	3.2	0 9	4.5	2 3	7.5
Vegetables	1 3	9.2	1 3½	7.8	2 4	7.8

MILK CONSUMPTION IN A NORTH WALES SLATE QUARRYING COMMUNITY.

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During the present century many investigations into the consumption of milk have been conducted in different towns and cities in Great Britain, and much useful information has been obtained from them. The general trends in consumption, and the influences of income, size, and constitution of households on consumption have been brought out. It is realised, however, that with the collection of such data the problem of milk consumption has by no means been solved. While it is important therefore to make a more searching analysis into the intricacies of consumers' purchasing habits, it is, nevertheless, equally important that information on milk consumption should be available for different types of communities.

Within recent years the Department* has conducted two milk consumption surveys. The first was made in the City of Cardiff in April, 1933, when 371 households of varying economic status were visited. The second was made in "a distressed area of South Wales" in July, 1934, when information was obtained from 602 households.** The data on which the present study is based was obtained from an area which possesses equally well-defined social and economic features as those previously surveyed.

Before proceeding to set out the chief results of this survey it may be useful to give a brief description of the geographical and economic background of the area to which the data refers.

The area surveyed covered the villages of Upper and Lower Corris, Aberllefenni and Esgairgeiliog, situated in the County of Merioneth. The villages are more or less contiguous and although they comprise parts of rural parishes they contain practically no agricultural land. The land rises sharply on both sides of the narrow valley in which the villages lie, and in places it reaches heights of over 1,000 feet. The herbage is naturally scanty and with the exception of very small areas is only suitable for sheep farming, while the mountain sides are strewn with huge boulders. Slate quarrying affords the only source of livelihood for the mass of the population of the villages. But although the regional setting of this locality is decidedly rural it cannot be said that the inhabitants are engaged in a rural industry as the process of quarrying is highly commercialised and keen competition exists between different kinds of roofing materials. This community therefore possesses certain well-defined regional characteristics and it is instructive to make a study of its milk consumption habits and to compare the results with those obtained from some previous studies.

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The present information was obtained during the week July 4th—10th, 1937. The employment position at the quarries during this period was considered to be good. The general state of health of the community was quite normal, there being no epidemics nor abnormal volume of sickness which would be likely to affect the general level of milk consumption.

In the second milk consumption survey conducted by this Department particulars of household income were obtained and this procedure has again been adopted in the present study. In addition to the usual information on household constitution and quantities and values of fresh and other milks purchased, details of use made of fresh milk, number of retailers supplying milk at each household, and number of deliveries per household per day were sought.

Such information was obtained from 185 households containing a total of 596 persons. The average size of household was therefore 3.22 persons which was rather below that estimated for England and Wales. Of the total persons 448 were adults (that is above the age of 14), 73 were between 7 and 14, and 75 under 7 years of age. The heads of most of the households were quarrymen, although the sample did include certain members of the professional and business classes. The average household income worked out at £2 3s 9d., and the per capita income at 13s. 7d. per week. This latter amount was somewhat higher than the corresponding figure for the Rhondda survey. The average consumption of fresh milk per person in the present study, however, worked out at 3.21 pints which was considerably higher than that for the Rhondda survey.

For purposes of comparison the relevant data are set out below.

	Rhondda Valley.	*Present Survey.*
Household Income	£2 15 1½	£2 3 9
Income per Person	£0 11 5	£0 13 7
Persons per Household	4.83	3.22
Fresh Milk purchased (pints per person)	1.30	3.21
Cost (Pence per person)	3.95	9.63

Consumption in the quarrying community was over twice as great as that in the South Wales coal-mining region, although income per person was only slightly lower in the latter. But it must be realised that these are two different kinds of communities. In the Rhondda Valley a greater proportion of income is spent on non-food requirements mainly because opportunities for a more varied standard of living exist there, while this is not the case in this quarrying community.

This greater consumption of milk may perhaps also be due partly to differences in the nature of occupations in the two areas.

In previous milk consumption surveys the usual procedure was to set out the relation between income and consumption and the same method has been adopted in the present study. It has been found that a truer index of purchasing power is obtained by taking income per person rather than household income and for this reason the former method has been adopted. In the following Table the consumption and cost of fresh milk is given by income groups.

TABLE I.

Fresh Milk Consumption per Person per Week.

Income per Person.	*Average Income per Person.*	*Number of Households.*	*Average Size of Household.*	*Consumption.*	*Cost.*
	s. d.			*Pints.*	*Pence.*
Under 5/-	4 6	3	7.00	1.74	5.22
5/— 9/11	7 4	42	4.77	2.47	7.41
10/—14/11	11 3	62	2.71	3.32	9.96
15/—19/11	17 2	36	2.83	3.46	10.38
20/—24/11	21 9	21	2.06	3.87	11.61
25/—29/11	26 3	14	2.78	4.92	14.76
30/- and above	39 3	7	2.00	4.57	13.71
Average (or Total) Whole Group.	11 3	185	3.22	3.21	9.63

The income distribution was very asymmetrical. About a quarter of the households received less than 10 shillings per head per week, and almost 60 per cent received less than 15 shillings per head. Only 11.4 per cent of the households enjoyed per capita incomes in excess of 25 shillings.

Consumption increased from about 1¾ pints in the first group to about 4½ pints in the highest group, but that for the group with per capita incomes ranging from 25 shillings to 29s 11d. was almost 5 pints. But the number of households in the highest income group was very small. As in the case of previous surveys the relation between income and consumption of fresh milk is well brought out in this study. It will be observed from the above Table that the increase in consumption from one group to another was more marked in the lower than in the higher ranges.

It is true, of course, that there were quite wide variations in consumption within the income groups, but this is just what one would expect. Thus in the group with incomes ranging from 5s. to 9s 11d. consumption varied from 0.9 to 5.3 pints, but at the same time income varied from 5s. to 9s 6d. Similarly in the next group consumption varied from 1.4 to 7.0 pints, while income ranged from 10s. to 14s 4d. There was also a tendency for the size of household to fall with increasing income. But in the groups with income ranging from 10s. to 14s 11d. and 25s. to 29s. 11d. respectively, the average size of household was, to all intents and purposes, practically unchanged, yet consumption showed a steady increase.

When the households are grouped according to size we have the situation given in the following Table.

TABLE II.

Fresh Milk Consumption per Person per Week.

Number in Household.	*Number of Households.*	*Average Income per Person.*	*Consumption*	*Cost.*
		s. d.	*Pints.*	*Pence.*
1	18	15 6	4.36	13.08
2	60	17 8	4.00	12.00
3	40	14 11	3.45	10.35
4	36	14 1	3.09	9.27
5	14	11 10	2.76	8.28
6	7	11 9	2.85	8.55
7 and over	10	6 9	2.24	6.72
Average Whole Group.	185	13 7	3.21	9.63

A feature of this sample was the number of persons living alone. There were eighteen such households, comprising almost 10 per cent of the total. About one-third only contained two persons, and just over one-fifth three persons. Only 17 per cent of the total households contained more than five persons.

Milk consumption declined progressively with increase in the size of household from 4.36 pints in the households consisting of one member to just under 2¼ pints in those consisting of seven or more persons. Of the eighteen persons living alone sixteen were in the old-age pensions class, while the other two had private means. It may seem remarkable that this group showed the highest consumption, but this may be due to the fact that a half-pint was the smallest quantity supplied. Seven households made daily purchases of this minimum quantity, although three households only received milk on alternate days. One person with a weekly income of £4 0s 0d. received a quart per day. This feature of decreasing consumption with increasing size of household has been brought out in previous studies. But it has also been noted that income varies inversely with size of household. In the present study income per person declined from 15s. 6d. in the first group to 6s. 9d. in the largest households, although the per capita income in the households containing two persons was somewhat higher than that for those only containing one person. It appears therefore that decreasing purchasing power is also an element accounting for this decrease in milk consumption with increasing size of household, and that in placing size of household alongside milk consumption, and then income alongside milk consumption separately, we are in fact measuring a part of the same factor twice over, as income per person and size of household are not independent of each other. Despite the interdependence of these two factors it appears to be perfectly legitimate to make a general statement to the effect that the consumption of fresh milk is to a very great extent a matter of income per person.

It has been suggested that in order to find the true relationship between income and consumption the other variable factor, namely size of household, should be eliminated by taking households containing the same number of persons. In order that this may be done satisfactorily a very large number of households of equal sizes but of varying economic status would be required. It is not possible to do this in the present study, but the tendency for consumption under such conditions to increase with increasing income is brought out by taking a very modest sample.

In the following Table the sixty households each consisting of two persons have been grouped according to per capita incomes.

TABLE III.

Fresh Milk Consumption per Person per Week in Households containing 2 Persons.

Income per Person.	*Number of Households.*	*Consumption.*
		Pints.
Up to 5/-	6	2.79
5/- to 10/-	12	3.86
10/- „ 15/-	3	4.66
15/- „ 20/-	19	3.74
20/- and above......	20	4.60

The amount drunk raw varied from 0.19 pints in the lowest income group to 1.00 pints in the highest and the proportions from 11.0 to 21.9 per cent respectively, but no clear trend is perceived. The amount thus used rose sharply in the second income group, and accounted for almost a quarter of total consumption.

TABLE VI.

Utilisation of Fresh Milk by Size of Household.

Number in Household.	*Weekly Consumption per Head per Week (pints)*					*Percentage of Total.*				
	Drunk as Milk.	*Milk Drinks, etc*	*In Cooking,*	*In Tea, etc*	*Total.*	*Drunk as Milk*	*Milk Drinks, etc.*	*In Cooking*	*In Tea, etc.*	*Total.*
						%	%	%	%	%
1	0.72	0.11	1.42	2.11	4.36	16.6	2.5	32.5	48.4	100.0
2	0.49	0.03	1.87	1.61	4.00	12.1	0.8	46.8	40.3	100.0
3	0.62	0.16	1.39	1.28	3.45	18.0	4.8	40.2	37.0	100.0
4	0.71	0.08	1.34	0.96	3.09	23.0	2.6	43.5	30.9	100.0
5	0.51	0.03	1.25	0.97	2.76	18.6	1.0	45.2	35.2	100.0
6	0.86	0.05	1.14	0.80	2.85	30.4	1.7	40.0	27.9	100.0
7 and over	0.39	—	0.98	0.87	2.24	17.4	—	43.7	38.9	100.0
Average	0.59	0.07	1.38	1.17	3.21	18.4	2.2	43.1	36.3	100.0

It has been noted above that most of the milk consumed by all households was used for cooking purposes. This was so in each income group with the exception of that with per capita incomes ranging from 5s. to 9s 11d. in which case the same amounts were used in tea, etc. as were used for cooking purposes.

Very little milk was used to make milk drinks, such as Ovaltine, and Bournvita, etc. Over the whole sample it only accounted for 2 per cent of the total milk purchased.

In Table VI the households have been grouped according to size.

The amounts used in tea, coffee, and cocoa, and for cooking purposes tended to follow the trend in total consumption and to decrease with increase in the size of household. That utilised in the former way decreased from 2.11 pints in the households containing only one person to 0.80 of a pint in those with six persons, although the amount for the largest households was slightly above this latter figure. The amount of milk used for cooking rose from 1.42 pints in the single households to 1.87 pints in those consisting of two persons but fell consistently thereafter to 0.98 pints in the largest group.

The quantities drunk raw and used with milk drinks, however, showed no such trend. In the one person households 0.72 of a pint comprising 16.6 per cent of the milk used was drunk raw, and in the households containing seven or more persons 0.39 of a pint or 17.4 per cent of the total for the group. But in the households consisting of six persons 0.86 of a pint comprising almost one-third of the total was used in this manner.

Similar information for households with and without children is given in Table VII.

It has already been noted that the households with children consumed about one pint per week less than did those without children. It is seen from Table VII, moreover, that the former households consumed about two-thirds of a pint less milk in cooked form, and about half a pint less in tea, etc. than the latter; but the consumption of raw milk by households with children was about one-tenth of a pint greater than that of the households composed of adults only. The total fresh milk consumed by the households with children was below the amount recommended in some quarters and considerably below the optimum amount. It appears that the heads of these households endeavoured, to a certain extent, to meet the increased requirements of their children for fresh milk, but it seems that the greater consumption of raw milk by these households was effected at the cost of a considerable curtailment in purchases for other uses.

TABLE VII.

Utilisation of Fresh Milk in Households with and without Children.

Household Types.	*Weekly Consumption per Head per Week (pints)*					*Percentage of Total.*				
	Drunk as Milk	*Milk Drinks, etc.*	*In Cooking.*	*In Tea, etc.*	*Total*	*Drunk as Milk*	*Milk Drinks, etc.*	*In Cooking*	*In Tea etc*	*Total.*
Without Children.	0.53	0.07	1.78	1.43	3.81	% 13.9	% 1.8	% 46.7	% 37.6	% 100.0
With Children (Number)										
1	0.53	0.13	1.40	1.12	3.18	16.7	4.1	44.0	35.2	100.0
2	0.77	0.04	1.06	0.95	2.82	27.3	1.4	37.6	33.7	100.0
3	0.63	—	0.64	0.78	2.05	30.7	—	31.2	38.1	100.0
4 and over	0.63	0.04	0.95	0.85	2.47	25.5	1.6	38.5	34.4	100.0
All with Children.	0.63	0.07	1.10	0.97	2.77	22.8	2.5	39.7	35.0	100.0
Average Whole Group.	0.59	0.07	1.38	1.17	3.21	18.4	2.2	43.1	36.3	100.0

Delivery of Fresh Milk.

Some information on the delivery of fresh milk was also obtained by this survey.

TABLE VIII.

Number of Deliveries per Day.

Income Groups	*1*	*2*	*3*	*4*	*Total.*
Up to 5/-	1	2	—	—	3
5/- — 9/11	19	21	1	1	42
10/- — 14/11	42	20	—	—	62
15/- — 19/11	19	13	4	—	36
20/- — 24/11	8	12	—	1	21
25/- — 29/11	8	6	—	—	14
30/- and above	5	2	—	—	7
Total	102	76	5	2	185

In Table VIII the number of deliveries per day are set out for the different income groups. It will be observed that 102 households comprising 55 per cent of the total received one delivery per day. A further 76 households, or 41 per cent of the total had two deliveries per day. And these two groups together account for 96 per cent of the total sample. Of the households who had one delivery about four-fifths were in receipt of incomes below £1 per week, while 74 per cent of those who received two deliveries were within these income limits.

Quite a large proportion of the total households, however, received their milk supply from more than one retailer, while the actual position is given in the following Table.

TABLE IX.

Number of Retailers calling and Deliveries per Day.

Number of Retailers Calling.	*Deliveries per Day.*			
	1	*2*	*3*	*4*
1	102	26	—	—
2	—	49	—	1
3	—	1	5	—
4	—	—	—	1

The households who received their total supply from one retailer numbered 128, although 26 of these received two deliveries per day. Forty-nine households each received two daily deliveries from two retailers. The nature of the deliveries to the eight remaining households may be seen from the Table IX.

The proportions of total milk taken by the households when classified in this way are given in tabular form below.

	Per cent of	
	Households.	*Total Milk Taken.*
1 Retailer, 1 Delivery	55	84
1 ,, 2 Deliveries	14	5
2 ,, 2 ,,	27	9
Other Forms of Delivery	4	2
	100	100

It is seen that the 102 households comprising 55 per cent of the total sample took 84 per cent of all milk delivered. In the case of the households with other delivery systems, however, the quantity of milk received represented a smaller proportion than did numbers of households in them.

Milk in Schools.

In the schools in the area covered by the survey the supply of milk to school-children took the form of the provision of ⅓ pint Horlick's milk at ½d. a glass. Of the 148 children of school age in the sample only 25 or 17 per cent of the total participated in this scheme while two of these children only took milk at school during Winter. The per capita incomes of the households to which these children belonged ranged from 5s. 8d. to 24s. per week. Eighteen of the children, however, were from households with per capita incomes below 12s. A number of households whose children did not take advantage of the scheme stated that they fully realised its value but could not afford to give the children money to take milk at school.

Consumption of Other Milkstuffs.

The position with regard to expenditure on other milkstuffs is given in the following Table :—

TABLE X.

Total Household Expenditure on Other Milkstuffs.

Income per Person.	*No. of Households.*	*Whole Condensed.*	*Milk Powder.*	*Cream.*	*Total.*
		s. d.	*s. d.*	*s. d.*	*s. d.*
Under 5/-	—	—	—	—	—
5/- — 9/11	8	8 1	5 7	1 8½	15 4½
10/- — 14/11	10	3 1	2 3½	2 10½	8 3
15/- — 19/11	4	0 3½	—	3 0	3 3½
20/- — 24/11	7	0 8½	3 6	3 1	7 3½
25/- — 29/11	8	0 10½	—	3 4	4 2½
30/- and above	—	—	—	—	—
Total	37	13 0½	11 4½	14 0	38 5

Of the 185 households in the sample only 37 recorded purchases of tinned and other forms of milk. The total expenditure on these items amounted to 38s. 5d. which represented 8 per cent of that spent on fresh milk. The households in the lowest and highest income groups did not purchase any milkstuffs other than in a fresh form.

Expenditures by the 37 households on these three kinds of milkstuffs given in the Table accounted for somewhat over 30 per cent of the total in each case. The households with per capita incomes ranging from 5s. to 9s. 11d. showed the heaviest purchases of condensed milk, while those in the higher income ranges showed the heaviest outlay on cream. About two-thirds of the expenditure on the latter, moreover, was on the tinned variety.

Summary.

The data on fresh milk consumption presented in this study shows that consumption in a quarrying village follows the same general trends as elsewhere. It would appear from a comparison between the results of this and the previous milk consumption surveys conducted by this Department that there are very marked differences in quantities used in different localities. Reference has already been made to the wide disparity between the consumption of fresh milk in the Rhondda Valley and in the area now under consideration, although per capita incomes were not so very much different. But it was known that consumption in the Rhondda Valley was very low. Yet that in the quarrying community cannot be regarded as high although it is just possible that some of the conditions of supply of milk tended to keep down consumption. No graded milk was available at the time this survey was conducted, while very little milk was bottled. Many householders remarked that they would take a greater supply if they could purchase Tuberculin Tested milk. It also transpired that there was a shortage of milk in Winter, and even in Summer in one of the villages. Such conditions evidently militated against expansion in consumption.

Under such conditions some households resorted to tinned condensed milk, but others managed with a decreased supply of fresh milk. In fact it appeared that there was a pronounced dislike for the former. This is borne out by the fact that only 6 per cent of the households made purchases of this form of milkstuff. And this feature again affords an illustration of the differences in the consuming habits of the inhabitants of this community and those of the Rhondda. In the latter area great reliance was placed on condensed milk, and it was a very common substitute for fresh milk, especially in the lower income groups. Many households had acquired such a taste for it that it was more highly appreciated than fresh milk. In the North Wales community, however, the reverse was the case.

The importance of income as a factor in the determination of fresh milk consumption was again brought out in this survey. It is realised of course that there are other and more subtle factors in operation which influence milk consumption in a greater or lesser degree in all localities, and that together they may have quite an appreciable effect on consumption. But in the area covered by the present survey fresh milk was highly appreciated, so much so that condensed milk, even in the lower income groups and under conditions of scarcity of fresh milk, made little headway as a substitute. One of the striking results of this survey was the large number of households who expressed the desire to take more fresh milk but were unable to do so as they could not afford it. In the lower income ranges it is probable that increases in per capita incomes would make for relatively great increases in the consumption of fresh milk even though the amounts purchased and consumed are influenced by other factors, always providing that adequate and suitable supplies are available.

AGRICULTURAL REQUISITE SOCIETIES IN WALES.

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An examination is periodically made of the condition of the agricultural co-operative movement in Wales and the results are published in this Journal.* By reference to previous articles, it is possible to follow the general development of the movement since 1930. During this period the requisite societies of the Principality have made appreciable progress, although during the last two years the total number has shown a slight fall. This decline is due to the disappearance of a few of the weaker societies. but these businesses were comparatively unimportant.

The success of the movement may be gauged from the increase both in membership and in turnover. Membership in fact has risen by 23 per cent. since 1931 and continues to show a steady advance from year to year. At the present time about half the farmers of Wales are members of agricultural co-operative societies. The turnover has also shown a rapid rise. Between 1933 and 1937 there was an increase of 58 per cent. and the total is now fast approaching £2 millions a year. This rise is of course partly due to the rise in the general price level, but when due allowance has been made for this factor the total tonnage handled has shown a steady advance (See Table I).

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*This Journal, Vol. X., 1934, and Vol. XIII., 1937.

TABLE I.
Agricultural Co-operation in Wales.

Year.	*No. of Societies.*	*No. of Members.*	*Turnover.*
			£
1935	83	26,709	1,469,823
1936	81	27,228	1,602,680
1937	79	27,863	1,852,846

Sales of farm requirements alone have shown a rapid rise. Between 1933 and 1937 there was an advance of 54 per cent. and this occurred in spite of the fact that during the same period the number of societies fell slightly. The movement does not suffer any real loss with the disappearance of societies which are unable to hold their own. It is more desirable to permit bigger and stronger societies to open branch depots and to cater for farmers' requirements in such areas. This is now the plan generally adopted. The formation of a large number of comparatively small businesses is not encouraged. On the other hand existing societies, especially those with long experience, are gradually spreading over ever-widening areas, and as a result the movement is becoming more firmly established. Some of the requisite societies handle small quantities of farm products, but in recent years this feature has shown a tendency to decline. The processing and selling of farm products is becoming rather specialised and some of the work which was formerly done by the requisite societies is being undertaken by either the statutory marketing boards or by co-operative marketing societies established for the purpose (See Table II).

TABLE II.
Cash Turnover of Requisite Societies.

Year.	*No. of Societies.*	*Cash Turnover.*		
		Requisites.	*Produce.*	*Total.*
		£	£	£
1935	60	1,323,175	30,163	1,353,338
1936	59	1,434,736	21,735	1,456,471
1937	58	1,639,648	20,822	1,660,470

TABLE III.

Classified Sales (56 Societies).

	1935	*1936*	*1937*
	£	£	£
Feedingstuffs	738,428	1,044,453	1,208,618
Implements	12,424	18,861	23,581
Seeds	28,385	42,110	48,187
Fertilisers	59,299	82,433	130,203
Other	140,890	197,335	206,873
Total	979,426	1,385,192	1,617,462

The general nature of the trade of requisite societies shows no important change, feedingstuffs account for about three-quarters of the total sales. The demand for feedingstuffs in the case of several societies has increased considerably in recent years with the movement towards the preparation of balanced rations for livestock. Several businesses have obtained equipment for the purpose of preparing special rations such as dairy and feeding cakes, pig and poultry foods. This work might be extended as many more societies could undertake it for the benefit of their members (See Table III).

The complete process of preparing rations can be carried on at a cost of 12 to 13 shillings a ton.* Some societies do a good deal of cereal grinding and dry mixing of feeds and this method is also proving very popular. It is felt that by undertaking such work societies are able to render increasing services to members. With the reduction in the arable area of Wales during the post-war years, farmers have been obliged to purchase increasing quantities of their stock feed requirements. They have also attempted to obtain such feed in a form that involves the minimum expenditure on labour in handling it. At first it was the proprietary compounds that met this need and in consequence the demand for them rapidly increased.

It is essential that co-operative societies should meet this challenge and keep abreast of the times. They must provide feedingstuffs in the form in which they are now required. In view of the increasing extent to which proprietary compounds are displacing straight cakes as livestock feed, a society which merely sells such compounds is hardly performing the full service to members of which it is capable. Societies were at one time formed to meet the need of improving the quality of goods supplied to farmers. Reliance could be placed on commodities obtained through co-operative stores and under such conditions they served a very useful purpose. With the trend towards trade in proprietary compounds, that function is now of less importance. There is a danger therefore that requisite societies may become mere agents of certain trade associations and as such their potential usefulness might be severely curtailed and their status impaired. In fact the independence enjoyed by societies may be seriously jeopardised under such conditions, as the prices at which the goods are bought and sold would be dictated to them by the trade associations from which the products were obtained.

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*For Cost of Operations, see Report of Welsh Agricultural Organisation Society, 1936. p. 22.

TABLE IV.

Turnover of Feedingstuffs and Fertilisers corrected for change in Prices.

	Feedingstuffs.		*Fertilisers.*	
	Index of Prices. (1911—13 =100.)	*Corrected. Total.*	*Index of Prices. (1911—13 =100.)*	*Corrected. Total.*
		£		£
1935	87	848,767	88	67,385
1936	93	1,123,068	89	92,621
1937	120	1,007,182	93	140.003

Proprietary articles in fact form a large proportion of goods sold by societies to-day, including the bulk of the feedingstuffs, fertilisers and machinery. It is doubtful whether societies can adopt any measures that would combat this state of affairs in the case of fertilisers and machinery, but in regard to feedingstuffs the establishment of their own mixing and cubing plants might relieve them of a good deal of dangerous domination by trade associations.

TABLE V.

Estimated Change in Volume Sold over Previous Year.

Year.	*Feedingstuffs*	*Fertilisers*
	%	%
1935	+14.0	+29.9
1936	+32.0	+37.0
1937	—10.0	+51.0

There was a considerable rise in the value of feedingstuffs during 1936 and 1937, so an appreciable part of this rise in the latter year may be explained by the advance in prices. It is doubtful, however, whether Tables IV and V indicate the true position in 1937 as the prices of the bulk of the feedingstuffs sold by the societies did not change to such an extent as those on which the index number of feedingstuffs is based. Sales of fertilisers in 1937 were encouraged by the subsidy arrangements introduced in that year. In fact the demand for supplies of basic slag has recently been so intense that societies could have sold much larger quantities had they been able to obtain them from the manufacturers.

Profits.

The relation of gross profits to sales continues to show considerable variation, but the most common figures are in the region of 7 per cent to 10 per cent. Although a high gross profit does not necessarily indicate a strong position, a figure below 5 per cent of sales is generally too low. In the case of many proprietary articles, the margin of gross profit allowable is determined by the trade association concerned. The actual margin permitted varies considerably from one product to another, but when a variety of such commodities are handled the average margin is usually slightly over 10 per cent on the buying price. In the case of commodities sold as received and on which no costs are incurred apart from those connected with resale this margin should be sufficient to enable a society to show a net profit of about 3 per cent of sales (See Table VI).

TABLE VI.

Societies Grouped by Gross Profits as per cent. of Sales.

Gross Profit as per cent. of sales.	*Number of Societies.*		
	1935	*1936*	*1937*
Under 1.0	—	3	3
1— 2.9	2	1	1
3— 4.9	2	3	3
5— 6.9	7	7	9
7— 8.9	10	15	14
9—10.9	11	5	9
11—12.9	5	9	4
13—14.9	10	4	6
15—16.9	5	4	2
17 and over	4	4	3
Total	56	55	54

As in the case of gross profits, net profits in relation to sales show wide variation. Quite a number of societies are unable to show any net profits, which of course is an indication that some investigation into the methods of management is needed. Societies showing net profits of between 2 per cent and 4 per cent of sales

TABLE VII.

Societies Grouped by Net Profits as per cent. of Sales.

Net Profits as per cent. of Sales.	*Number of Societies.* 1935	1936	1937
Zero and below	8	5	8
0—0.9	8	4	5
1—1.9	9	12	5
2—2.9	8	7	9
3—3.9	3	8	8
4—4.9	11	7	9
5—5.9	6	7	4
6—6.9	—	2	4
7 and over	3	3	2
Total	56	55	54

appear to be in a sound position. Those that endeavour to exceed these figures may not be functioning to the best advantage either to themselves or to members. In cases where the reserve fund is low it is usually desirable to aim at a fairly high net profit so that allocations can be made to this fund, but in others it is usually more advantageous to sell goods at lower prices or provide greater services for customers. It is found that there is a fairly close relationship between the turnover of societies and the rates of gross and net profit (See Table VII).

In the case of the smallest group as indicated in Table VIII, the rate of net profit is somewhat low as trade costs are comparatively high. This is inevitable as many of the smaller societies have only recently been established. A society is often compelled to meet exceptional charges during the first few years of its existence, and is generally obliged to offer goods on very favourable terms and to provide attractive services to customers. In fact, it must

TABLE VIII.

Relation of Profits to Sales, 1934-7.

Size Group (Turnover).	*Aver. Gross Profit per Society.*	*Aver. Net Profit per Society.*	*Gross Profit per cent. of Sales.*	*Net Profit per cent of Sales.*
£	£	£	%	%
Under 5,000	226.0	38.9	8.8	1.5
5,000—10,000	662.0	221.7	9.2	3.3
10,000—20,000	1219.5	393.7	9.1	2.9
20,000—50,000	2941.5	798.6	9.9	2.7
Over 50,000	9635.1	3787.4	10.7	4.2
Average All Societies	2709.9	942.3	9.9	2.9

proceed to establish itself in the area in which it attempts to function and in doing so it cannot be expected to show as good profits as others which have overcome such initial difficulties (See Table VIII).

Membership.

One test of the success of the movement is provided by the number of people attracted and the rate at which new members join. There are about 40,000 farmers in Wales, but the number who hold land for agricultural purposes is probably about 50,000. At present the membership of agricultural co-operative requisite societies is about 25,000 so that at least half the potential members have already joined. During the last few years new members have been recruited at the rate of about 500 a year. Some new members in fact are being attracted owing to the definite financial advantages available, and others by a desire to take part in voluntary work associated with the movement. It is probable that many more farmers would join were they fully conversant with the history of the movement and the principles for which it stands.

TABLE IX.

Comparison of Membership by Counties.

County.	*No. of Holdings over 1 acre 1937.*	*No. of Farmers, 1931.*	*Members of Requisite Societies, 1937.*	
			No.	*Ratio of Members to Farmers.*
Anglesey	4,281	2,402	992	41
Brecon	2,356	2,039	949	47
Cardigan	5,556	3,806	3,478	91
Carmarthen	8.163	5,800	9,657	167
Caernarvon......	5,697	2,948	1,853	63
Denbigh	5,504	3,569	653	18
Flint	3,188	1,866	738	40
Glamorgan	4,307	3,186	1,110	35
Merioneth	2,620	1,980	2,070	104
Monmouth	4,022	2,656	486	18
Montgomery	5,093	3,657	1,479	40
Pembroke	5,630	4,027	2,133	53
Radnor	2,037	1,606	216	13
All Wales	58,456	39,542	25,814	65

Much greater progress has been made in some of the counties of Wales than in others. It appears from Table IX that the membership of requisite societies in Carmarthen and Merioneth exceeds the number of farmers. This may be due to a number of causes; some farmers may be members of more than one society whilst the membership may include employees and other persons who are not farmers. It may also be partly due to the overlapping of county boundaries with the result that farmers in one county may be included amongst the membership of societies situated in an adjoining county. In Carmarthenshire one society occupies a very strong position, namely the Carmarthen Farmers' Society. This society includes thirty-eight per cent of the total membership of the county and has eight branch depots. In many of the other counties there is considerable room for development work as in several regions only a small proportion of the farmers have joined. There is need of increasing the strength of the movement in such areas, and this must be done in the face of existing competitive conditions in the trade for agricultural requirements. The establishment of several new societies would probably be unwise, greater success would probably follow a concerted attempt to strengthen existing societies, and by opening depots in unexplored regions, contact could be made with a wider circle of farmers. This should be preceded by an active campaign which would serve to explain the advantages of co-operation.

TABLE X.

Sales per Member and per Employee, 1934-7.

Size Group (Turnover).	*Aver. Sales per Member.*	*Aver. Sales per Employee.*
£	£	£
Under 5,000	20.6	2042.2
5,000—10,000	32.1	3036.2
10,000—20,000	37.7	3425.7
20,000—50,000	52.0	3297.0
Over 50,000	79.1	3295.5
Average All Societies	44.3	3019.2

There is close relationship between the size of societies and the average sales per member as indicated in Table X. Although all societies trade with members and non-members there is considerable variation in the degree of loyalty shown by members. The bigger and stronger a society, the more confidence farmers place in it, as in general it exercises a greater influence in the area in which it operates than a small and rather weak society. Loyalty to a society is very largely dependent on the nature of the goods and services obtained in comparison with those available elsewhere. In the case of several commodities the manufacturers have their own selling organisations and employ travellers to solicit orders from farmers. Although societies have not yet adopted this method, it may be necessary for them to do so; this would enable the societies to keep in touch with farmers generally and would increase their interest in some of the problems of co-operation.

Over half the societies handle groceries and similar household requirements, and the proportion of such products to total sales varies widely; on the whole, however, such articles amount to 21 per cent of total sales of societies for which such information is available. Societies which handle a variety of domestic requirements are attracting the farm women folk in increasing numbers; this is a very desirable feature. When both the farm and farmhouse requirements can be obtained from the co-operative store, members can be more independent of other suppliers and are likely to show greater loyalty.

Expenses.

The expenses of running co-operative businesses vary to an appreciable extent with the nature of the goods handled. Trade costs per unit of goods sold would naturally be higher in cases where a large proportion of the commodities are sold retail, and also where some processing is done. The most important item in expenditure is the outlay on salaries and wages. On the whole this remains at about 4 per cent of sales. In cases where over a quarter of the goods handled are groceries and are sold in small lots, the total sales per employee are comparatively low and the cost of labour rises to about 5 per cent of sales. It does not follow, however, that net profits are lower in such cases as the distributors' margins on such goods are wider than in the case of other commodities (See Table XI).

TABLE XI.

Trade Costs.

Size Group (Turnover).	*Salaries and Wages per £100 Sales.*	*Other Costs per £100 Sales.*	*Total Costs per £100 Sales.*
	£	£	£
Under 5,000	4.5	4.0	8.5
5,000—10,000	4.4	2.6	7.0
10,000—20,000	4.7	3.5	8.2
20,000—50,000	3.9	4.3	8.2
Over 50,000	3.8	3.2	7.0
Average All Societies	4.3	3.5	7.8

"Other costs" in the case of stores doing an appreciable retail business are also somewhat higher than the average. On the whole, however, it is found that total trade costs in such cases amount to about 10 per cent of sales; this is about 2 per cent higher than the average of all societies. A considerable amount of processing of goods before resale also drives up trade costs but again this does not necessarily affect the net profits. In the case of goods prepared at the depots, such as balanced rations, societies are in a position to fix their own selling prices and in consequence make appropriate allowances for such costs.

It does not always follow, however, that the societies showing the lowest trade costs are the most successful from every standpoint. The cutting of costs sometimes means that certain necessary work is left undone. In some cases the appearance of the store might be considerably improved by a little judicious outlay. A store of attractive appearance is to-day a great asset, especially where groceries and similar domestic requirements are kept. Again, comparatively little is normally spent on advertising and it is not always wise to curtail expenditure on propaganda. It is true that many of the proprietary articles sold are advertised by the manufacturers, but this does not always help any particular store which stocks them, as such goods are generally available in a number of other stores. Societies which make a definite attempt to advertise their own store as such, apart from the goods which they sell, often find that the expenditure incurred is fully justified. In the performance of services to farmers, co-operative societies also need to be abreast of the times. Many of the large firms, with which they are in competition, employ experts to advise farmers in matters connected with the manuring of crops, the feeding of livestock and the treatment of plant and animal diseases. It may be inadvisable for co-operative societies to enter this field of work, but the employment of travellers to ascertain farmers' requirements and to solicit orders may be a sound practical proposition, especially for the larger societies.

Capital.

The proper use of capital is an important problem for all societies. The distribution of assets may be seen from Table XII.

TABLE XII.
Distribution of Assets of Requisite Societies, 1934-7.

Size Group (Turnover).	*Percentage in*				
	Real Estate.	*Investments.*	*Stock.*	*Debtors.*	*Cash.*
Under 5,000	17.2	9.2	13.8	52.1	7.7
5,000—10,000	9.3	15.4	16.9	41.4	17.0
10,000—20,000	19.1	23.4	14.6	35.5	7.4
20,000—50,000	17.0	6.6	14.8	52.2	9.4
Over 50,000	19.9	5.6	17.7	42.8	14.0
Average All Societies	16.4	12.0	15.6	44.8	11.2

Although some variation is shown, on the average one-sixth is sunk in land and buildings, and about one-eighth is invested outside the business. The investment of capital in real estate has been found to be a sound proposition when there are ample funds available. In some instances, however, notably in the case of new societies which have not had time to build up their reserves, it is usually better to arrange a mortgage on the property than to have an excessive proportion of the capital tied up in this way. As can be gleaned from Table XII, only a comparatively small proportion of the total capital is invested in other businesses ; what there is, however, is mainly in the form of shares in the Co-operative Wholesale Society. When a society is admitted to membership of the C.W.S. it takes up one £5 share for every two of its members, it need not pay the full value of the shares as a nominal deposit is accepted. Some financial advantage results to societies from membership of the C.W.S., as the dividend declared in recent years to members has been twice that paid to non-members.

TABLE XIII.

Borrowed Capital.

Size Group (Turnover).	Borrowed Capital to total Capital.	Distribution of Borrowed Capital.		
		Loans and Mortgages.	Trade Creditors.	Bank Overdraft.
£	%	%	%	%
Under 5,000	43.2	9.7	57.5	32.8
5,000—10,000	30.3	21.2	66.0	12.8
10,000—20,000	41.9	33.6	58.9	7.5
20,000—50,000	29.9	11.7	66.0	22.3
Over 50,000	27.1	24.6	64.1	11.3
Average All Societies	34.5	20.1	62.5	17.4

The extent to which a society borrows capital and the nature of the loans obtained is sometimes a good indication of the soundness of the business. On the whole societies borrow just over one-third of their trade capital. The smaller ones borrow more extensively, but such loans are usually in the form of bank overdrafts and do not usually extend over long periods. Societies should not be discouraged from borrowing where the capital obtained is needed for legitimate business uses. Borrowing in order to give excessively long credit to consumers, however, may be harmful to a society as it might inflate working costs unduly. First mortgages on the real estate are now being arranged at 4 per cent and in some areas at 4½ per cent. Some societies, however, are paying higher rates where mortgages were arranged before the fall in interest rates which occurred some six years ago (See Table XIII).

TABLE XIV.

Reserves of Capital.

Size Group (*Turnover*).	*Actual Reserves per Society.*	*Reserves as a per cent. of:*	
		Share Capital.	*Total Capital.*
£	£	%	%
Under 5,000	446	75.5	28.9
5,000—10,000	1,563	374.9	56.1
10,000—20,000	2,744	450.7	51.4
20,000—50,000	5,625	219.1	48.5
Over 50,000	13,945	155.2	56.8
Average All Societies	4,865	255.1	48.3

The problem of the reserve fund always deserves serious consideration. The rules adopted generally provide that after the payment of not more than 5 per cent interest on the paid up share capital, at least one-half of the profits shall be allocated to the reserve fund until it equals the share capital. From Table XIV it can be seen, except in the case of the smallest group, that reserves are far in excess of the share capital. Sums allocated to reserves, however, are usually invested in the business and are used in various ways as needed. There is no reserve fund in the strict sense in which this term is used in some other businesses. A reserve fund generally implies a sum invested outside the business, usually in Trustee Securities, which can be drawn on to meet financial difficulties which the business may encounter. Reserves of co-operative societies, however, are not dealt with in this way, but are reinvested in the business. In general this is a sound procedure as long as assets are not over-valued. If for some reason, e.g. loss of business, there is a rapid fall in the value of the assets, the reserve might quickly disappear with the result that liabilities exceed assets and then the business becomes insolvent.

It appears that the policy of some societies in dealing with the allocation of profits has served to restrict rather than encourage the development of the business. In some instances the issued share capital is ridiculously low in relation to the total capital employed. When reserves equal the share capital, the subsequent allocation of profits should be partly in the form of bonus shares. The most well balanced societies have in fact maintained a reasonable equilibrium between reserves and share capital.

One of the most important tests of efficiency is the relationship between debtors and sales. Some societies grant excessive credit and by so doing weaken themselves. Granting long credit often absorbs capital which is needed for other purposes, whilst on the

TABLE XV.

Relation of Credit to Sales.

Size Group (Turnover).	*Actual credit Granted per Society.*	*Debts as per cent. of Sales.*	*Debts as per cent. of Working Capital.*
£	£	%	%
Under 5,000	803	28.6	41.0
5,000—10,000	1,153	17.1	55.0
10,000—20,000	1,893	14.2	61.7
20,000—50,000	6,038	20.4	68.2
Over 50,000	13,759	15.2	56.8
Average All Societies	4,256	19.1	56.5

other hand excessive vigilance in enforcing payment for goods, at a time when farmers experience difficulty in meeting such debts, may result in the loss of customers. The extent to which debts are recoverable should be considered when placing a cash value on such assets. Reserves in many cases are extensively used for the purpose of granting credit and when debts are partly irrecoverable some of the reserve inevitably disappears. On the average, credit is granted for 70 days and although this may appear rather high, businesses which allow this period of credit do not normally suffer, although it means that in general just over one half of the working capital is employed in this work (see Table XV).

On the whole, agricultural co-operation in Wales is making steady progress. Competition to sell agricultural requirements is keen and societies cannot afford to stagnate. They render many services to farmers however, which cannot be easily evaluated. Some societies would be well advised to make greater efforts to increase their membership and more especially to encourage the younger generation of farmers to join. There is need of bringing the principles of co-operation to the notice of farmers in many parts of Wales and this might well repay the effort involved.

FINANCIAL RESULTS OF DIFFERENT TYPES OF FARMS IN WALES, 1936-7 AND 1937-8.

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Accounts are available for the same 56 farms for the years 1936-7 and 1937-8, and these have been classified into type-groups on the basis of knowledge of the farms and the composition of the receipts. Livestock and livestock products constitute the chief items of sales in all type-groups, although it is natural that there should be some variations in the proportions accounted for by sales of sheep, cattle, milk and dairy produce etc. in them. While it is fully realised that the number of records dealt with is small, it is felt that the information obtained from these farms provides some measure of the financial position of farmers in Wales during the period under review, and that the results also afford some indication of the economic situation of the main farming types in the Principality.

The total area of these farms together with the rents on a per farm and per acre basis are given in Table I. Acreages remained unchanged apart from some slight changes in both the Cattle and Sheep (Poor and Better Land) groups. Rentals have also remained practically the same for each type-group.

Description of Type-groups.

Cattle and Sheep (Poor Land). This group consists of 10 farms varying in size from 105 to 764 acres on land of poor quality at fairly high elevation. Five of these are below 200 acres and four between 250 and 350 acres. On the whole, rentals are low and average about 7s. 5d. per acre with variations between 2s. 9d. and 12s. 8d. per acre. Sales are mainly of store cattle and sheep. Some butter is made but sales of liquid milk appear to be increasing. Of the total persons employed (including the occupier and his wife) about 36 per cent are hired workers.

Cattle and Sheep (Better Land). This group is represented by a smaller type of holding on better land which allows of more intensive stocking. While the average size is about 197 acres the range is from 61 to 486 acres, but over half the farms are below 150 acres. Only a small proportion of the farms are below 50 acres. The rents range from 11s. 8d. to 31s. 3d. per acre with an average rental of about 18s. per acre. Sales of cattle and sheep (both fat and store)

TABLE I.

Total Acres, Average Size of Farm and Rentals.

Type-Group	*Cattle and Sheep (Poor Land)*		*Cattle and Sheep (Better Land)*		*Mixed Farms*		*Dairy Farms (27-40% receipts from Milk)*		*Dairy Farms (over 40% receipts from Milk)*		*All Farms*	
Year	*1936–7*	*1937–8*	*1936–7*	*1937–8*	*1936–7*	*1937–8*	*1936–7*	*1937–8*	*1936–7*	*1937–8*	*1936–7*	*1937–8*
Number of Farms	10	10	12	12	10	10	11	11	13	13	56	56
Total Acres	2648	2569	2361	2353	1039	1039	1304	1304	1328	1328	8680	8593
Average Size of Farm (Acres)	265	257	197	196	104	104	119	119	102	102	155	153
Rent per Farm	£98.4	£94.9	£177.2	£177.3	£130.7	£130.7	£142.9	£142.3	£129.8	£129.8	£137.1	£136.4
Rent per Acre	7s. 5d.	7s. 5d.	18s. 0d.	18s. 1d.	25s. 2d.	25s. 2d.	24s. 1d.	24s. 0d.	25s. 4d.	25s. 4d.	17s. 8d.	17s. 9d.

form the major part of the receipts while some attention is given to the production of pigs and poultry. Crop sales are of minor importance. About 55 per cent of the total persons employed on these farms consists of hired labour.

Mixed Farms. A characteristic feature of this group is that more prominence is given to the cultivation of arable crops while the output of pigs, poultry and eggs are higher than in the other type-groups. The average size is 104 acres with variations from 30 to 296 acres. Rentals range from 12s. 4d. to 45s. 5d. per acre with an average of 25s. 2d. per acre. Including the farmer and his wife about 51 per cent of the total persons employed consists of hired labour.

Dairy Farms (27-40 *per cent Receipts from Milk*). This group resembles the Mixed Farms in that a fair amount of the land is under arable cultivation and there is some sale of crops. Sales of milk and pigs are the main sources of income in this group. The farms range in size from 18 to 335 acres and average 119 acres. Rentals vary from 15s. to 56s. 4d. with an average rental of about 24s. per acre. About 53 per cent of the total labour (including that of the occupier and his wife) is hired labour.

Dairy Farms (*Over* 40 *per cent Receipts from Milk*). About 93 per cent of the land in this group is under pasture and about 60 per cent of the receipts are obtained from the sale of liquid milk. The farms range in size from 41 to 249 acres with a general average of 102 acres. Rents show considerable variation and range from 9s. 8d. to 66s. 2d. with an average rental of about 17s. 9d. per acre. Hired labour in this group represents about 61 per cent of total labour employed.

Land Utilisation.

In all groups the greater part of the land is under grass. In fact, tillage land did not exceed 10 per cent of the total area in either year. The proportion of the land under crops is highest on the Mixed Farms and on the Dairy Farms (27-40 per cent receipts from milk), but even in these type-groups the tillage area did not reach 14 per cent of the total farm area. In the other type-groups about 7 to 8 per cent of the land is under arable crops. There are also some variations in the nature of crops grown. Oats are the most important cereal crop on all types of farms, the acreage under this crop varying from about 36 to 60 per cent of the total arable crops. Wheat is of moderate importance in all type-groups except the Cattle and Sheep (Poor Land) while barley is of least importance in the Cattle and Sheep (Poor and Better Land) groups. On the

TABLE II.

Arable Land, Hay and Pasture per 100 acres.

Type-Group	*Cattle and Sheep (Poor Land)*		*Cattle and Sheep (Better Land)*		*Mixed Farms*		*Dairy Farms (27—40% receipts from milk)*		*Dairy Farms (over 40% receipts from milk)*		*All Farms*	
Year	*1936–7*	*1937–8*	*1936–7*	*1937–8*	*1936–7*	*1937–8*	*1936–7*	*1937–8*	*1936–7*	*1937–8*	*1936–7*	*1937–8*
Crops	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
Corn	5.6	6.0	5.6	7.1	10.3	9.7	9.0	10.0	4.8	5.1	6.6	7.2
Other Crops	2.4	2.1	2.3	1.8	2.9	2.5	2.4	3.7	2.4	2.1	2.4	2.3
Total Arable	8.0	8.1	7.9	8.9	13.2	12.2	11.4	13.7	7.2	7.2	9.0	9.5
Hay	10.6	11.4	17.4	16.6	22.0	22.9	27.0	24.1	28.4	27.1	19.0	18.6
Pasture	21.9	21.6	43.1	42.8	47.8	47.9	54.5	55.1	55.3	57.4	40.8	41.2
Rough Pasture	59.5	58.9	31.6	31.7	17.0	17.0	7.1	7.1	9.1	8.3	31.2	30.7
Total Pasture	92.0	91.9	92.1	91.1	86.8	87.8	88.6	86.3	92.8	92.8	91.0	90.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Dairy Farms (over 40 per cent receipts from milk) there is no mixed corn grown and very little on the Cattle and Sheep (Better Land) group. Other type-groups show a fair proportion of the land under this crop in 1937-8. More prominence is given to the growing of potatoes on the Dairy Farms (over 40 per cent receipts from milk) and on the Mixed Farms than in the other type-groups. The cultivation of turnips, swedes and mangolds is of least importance on the Cattle and Sheep (Poor Land) group but the acreage under rape and kale is considerably higher than in the other type-groups.

There are some changes in the acreages under the different kinds of crops in the two years under review both in the type-groups and for all farms taken together. Over all farms there is an increase of about 5 per cent in the area under arable crops and about 9 per cent in the area under corn crops in 1937-8. Acreages under all other crops were lower in 1937-8 except rape and kale which shows an increase of nearly 14 per cent.

The Cattle and Sheep (Poor Land) farms show on an average a reduction of 2 per cent in arable acreage in 1937-8. Within the arable land there is evidence of a shift from wheat and oats to the growing of mixed corn in 1937-8 and the acreage under total corn crops increased by 4 per cent. All root crops except turnips and swedes declined in acreage in 1937-8.

The Cattle and Sheep (Better Land) farms show an expansion of 12 per cent in the acreage under arable crops. The acreage of wheat and oats is larger and that of barley and mixed corn smaller. Taken together, the acreage under corn crops increased by 25 per cent in 1937-8. With the exception of the acreage under potatoes, which increased by 11 per cent, that under all other root crops declined. The acreage cut for hay shows a reduction of 5 per cent in 1937-8.

The Mixed Farms show a decline of 7 per cent in arable crops and 6 per cent in corn crops in 1937-8. The acreage under mixed corn remains unchanged. Barley and wheat have declined and there has been some expansion in the acreage under oats. In the case of rape and kale there has been some increase in acreage grown, but roots and potatoes have declined. There is an increase of about 4 per cent in the acreage under hay.

Dairy Farms (27-40 per cent receipts from milk) show an expansion in the arable crop area of 20 per cent and an increase in the acreage under corn of 11 per cent. Of the cereal crops, wheat, barley and mixed corn show increases at the expense of the oat crop. The area under potatoes remains unchanged; turnips and swedes have declined, while the acreage under root crops (particularly rape and kale) have increased. The acreage cut for hay fell by 10 per cent.

Dairy Farms (*over* 40 *per cent receipts from milk*) show practically the same area under arable crops in both years but there have been changes in the nature of the cropping. The corn area has risen by 5 per cent with an expansion in the acreage under wheat and oats, and a decline in the acreage under barley. Potatoes remain at exactly the same acreage as in the previous year, but all other crops have declined.

Livestock Carried.

An indication of the differences in farming practices in these type-groups is afforded by the variations in numbers and classes of livestock. On the basis of livestock carried per 100 acres, the type-groups other than the Cattle and Sheep (Poor and Better Land) carry a larger head of cattle, pigs and poultry and a lower number of sheep. The Dairy Farms (27-40 per cent receipts from milk) and the Mixed Farms carry over three times as many pigs as the Dairy Farms (over 40 per cent receipts from milk) while the Mixed Farms carry about twice as many poultry and sheep as do the two Dairy groups.

A comparison of the livestock records for the two years indicates that over all farms there has been a slight increase in the number of 'work' horses. Dairy cows and 'other' cattle showed practically no change. Some slight increase occurred in the number of breeding ewes and 'other' sheep increased by about 6 per cent. Total pigs declined by about 10 per cent, but the number of breeding sows increased by about 6 per cent. While poultry have declined by about 13 per cent, the number of laying birds have been fairly well maintained.

The data for the different type-groups do not indicate any great changes in numbers of horses. With the exception of an increase of 4 per cent in the dairy cows on the Dairy Farms (over 40 per cent receipts from milk), and a reduction of 4 per cent on the Dairy Farms (27-40 per cent receipts from milk), the cow population remains very much the same in both years. Numbers of 'other' cattle show slight increases in the Cattle and Sheep (Poor Land) group and on the Dairy Farms (Over 40 per cent receipts from milk) while some decline is noticeable on the Mixed Farms. The sheep flocks (both breeding ewes and 'other' sheep) have increased in all type-groups except the Cattle and Sheep (Poor Land) where a reduction of 7 per cent is shown in 1937-8. On the Dairy Farms (over 40 per cent

TABLE III.

Number of Persons Employed (per Farm).

Type-Group	*Cattle and Sheep (Poor Land)*		*Cattle and Sheep (Better Land)*		*Mixed Farms*		*Dairy Farms (27—40% receipts from milk)*		*Dairy Farms (over 40% receipts from milk)*		*All Farms*	
Year	*1936–7*	*1937–8*	*1936–7*	*1937–8*	*1936–7*	*1937–8*	*1936–7*	*1937–8*	*1936–7*	*1937–8*	*1936–7*	*1937–8*
Farmer and Wife	0.8	0.9	0.5	0.7	0.9	0.8	0.8	0.8	0.7	0.8	0.8	0.8
Other Family Labour	1.0	0.8	1.1	1.0	0.7	0.6	0.4	0.4	0.4	0.4	0.7	0.6
Total Family Labour	1.8	1.7	1.6	1.7	1.6	1.4	1.2	1.2	1.1	1.2	1.5	1.4
Hired Labour	1.1	1.0	2.1	2.1	1.5	1.6	1.6	1.4	2.1	2.0	1.7	1.7
Total persons including Farmer and Wife	2.9	2.7	3.7	3.8	3.1	3.0	2.8	2.6	3.2	3.2	3.2	3.1
Total persons excluding Farmer and Wife	2.1	1.8	3.2	3.1	2.2	2.2	2.0	1.8	2.5	2.4	2.4	2.3
Total persons including Farmer and wife per 100 acres	1.1	1.1	1.9	2.0	3.0	2.9	2.4	2.3	3.2	3.1	2.1	2.0

receipts from milk) there is practically no change in the sheep population as between the two years. In four out of the five type-groups there has been a reduction in total numbers of pigs but the records indicate an increase in the number of breeding sows in three of the type-groups. Only on the Cattle and Sheep (Poor Land) farms has there been a decline in the number of breeding sows. A reduction in number of poultry occurred in all type-groups in 1937-8.

Number of Persons employed per Farm.

On the whole, numbers of hired workers and total personnel on these farms changed but slightly during these two years. (See Table III). Employment of family labour appears to be greater in the Cattle and Sheep (Poor Land) group while for the other type-groups the labour contribution of hired workers exceeds that of family labour. Over all farms female labour averaged about one-sixth of total persons employed and varied from about one-fourth on the Cattle and Sheep (Poor Land) to about one-seventh on the Dairy Farms. When the manual labour for each of the type-groups is expressed in terms of persons per 100 acres, the average size of the farm and the quality of the land appears to have some bearing on the numbers employed. Persons employed per 100 acres averaged about 3 on the Dairy Farms (over 40 per cent receipts from milk) and on the Mixed Farms. The corresponding figure for the Dairy Farms (27-40 per cent receipts from milk) was about 2¼, on the Cattle and Sheep (Better Land) about 2, and in the case of the Cattle and Sheep (Poor Land) only 1 person per 100 acres was employed.

Farm Capital.

The farm capital is the current money value of livestock and 'deadstock' (implements, etc.), tenants' fixtures, crops growing and harvested and the figures shown are the means of the opening and closing valuations. The principle adopted for valuation is as follows :—Breeding Stock, i.e., herd of cows or flock of ewes are valued on "standard values" which are not changed with temporary changes in market value. Crops to be consumed by stock are also valued on this basis. Livestock and produce expected to be ready for sale in the year following day of valuation are assessed as nearly as possible according to market values. Tenants' fixtures, implements and machinery are depreciated at standard rates, while current repairs, etc., are charged in expenses. Additions to implements are included in expenses, but are then carried to the Capital Account. On this basis the average capital invested per farm as per acre for the different type-groups is as follows :—

	Capital. *Per Farm.* *1936-7*	*Capital.* *Per Farm.* *1937-8*	*Capital.* *Per Acre.* *1936-7*	*Capital.* *Per Acre.* *1937-8*
	£	£	£	£
Cattle and Sheep (Poor Land)	1,048	1,076	3.9	4.1
Cattle and Sheep (Better Land)	1,450	1,507	7.3	7.6
Mixed Farms	1,260	1,283	12.1	12.3
Dairy Farms (27-40 per cent receipts from milk)	1,265	1,314	10.6	11.0
,, ,, (over 40 per cent receipts from milk)	1,149	1,197	11.2	11.7
All Farms	1,238	1,280	7.9	8.3

By far the greater proportion of the capital in all the type-groups is invested in livestock and especially in cattle. The records indicate that the proportion of capital invested in sheep decreases from the poorer to the better quality land. Other facts which emerge from the records are the comparatively large amount of capital invested in pigs in two of the farm type-groups—namely, the Mixed Farms and the Dairy Farms (27-40 per cent receipts from milk). The Mixed Farms have also quite a considerable proportion of capital invested in poultry.

As compared with 1936-7, there is a slight increase in the farm capital over all type-groups and in some cases this is partly accounted for by the larger head of stock carried and partly by improvement in prices of some classes of livestock. There are, however, no outstanding changes in the distribution of the capital invested, except that some increase is noticeable in 1937-8 in the capital invested in cattle and sheep for each type-group. The amount of capital invested in pigs in 1937-8 was somewhat greater in all type-groups with the exception of the Mixed Farms and Dairy Farms (over 40 per cent. receipts from Milk). Apart from the Cattle and Sheep (Better Land) and the Dairy Farms (27-40 per cent. receipts from milk) the capital invested in poultry declined in 1937-8. As a result of purchases made the capital invested in implements showed some increase for all the type-groups except in the Cattle and Sheep (Better Land) group. Compared with 1936-7, the average farm capital for the 56 farms increased by 3 per cent. with variations between the different type-groups of from 2 to 4 per cent.

Receipts.

Receipts are made up as follows :—Sales, value of farm produce consumed by the household and rent of the farm house at rateable value. Sales of cattle and wheat are inclusive of subsidy payments. The receipts are influenced not only by types and quantities of produce sold but also by the prices obtainable for them. All these factors have been responsible to a greater or lesser degree for the variation in the receipts between 1936-7 and 1937-8. The average turnover and the composition of the total receipts per farm for each type-group are shown in Table IV. Over all farms receipts remain practically the same in both years—the decline in 1937-8 being only slightly less than £4 per farm. But the position is somewhat different when the type-groups are considered. The Dairy Farms (27-40 per cent. and over 40 per cent. receipts from milk) show an increase in receipts in 1937-8 of about £52 and £65 per farm respectively, while the Cattle and Sheep (Better Land) group shows practically no change. On the Mixed Farms receipts have declined by about £186 per farm and on the Cattle and Sheep (Poor Land) by about £63 per farm. Over all farms in 1937-8 there has been a decline in the receipts from all livestock and livestock products except those from sales of cattle and milk. It might have been expected that the receipts from cattle would have shown some reflection of the general improvement in cattle prices which occurred during 1937-8, but over all farms the increase in receipts from this source was only about 1 per cent. Except for a few minor changes in the different type-groups, the cattle population on the 56 farms remained very much the same in both years. On the Mixed Farms there was a decline of about 13 per cent in cattle receipts, while the Dairy Farms (27-40 and over 40 per cent receipts from milk) showed an increase of 8 and 15 per cent respectively. Other type-groups showed practically no variations in receipts from cattle during the two years. Receipts from milk for all farms were much higher in 1937-8, the increase amounting to 11 per cent. This was partly due to improvement in prices and partly to the change-over on some farms from the production of butter to the sale of liquid milk. Sales of butter declined for all type-groups in 1937-8. While the records indicate a slight increase in the number of sheep kept there was a decline of 4 per cent over all farms in the receipts from sheep and wool. This decline is probably the result of the severe drop in prices of sheep and wool which was experienced during 1937-8. The reduction in receipts is most noticeable in the Cattle and Sheep (Poor Land) group where the decline amounts to 22 per cent. In two of the type-groups (Cattle and Sheep [Better Land] and the Mixed Farms) there was some improvement in the revenue from sheep and wool. Numbers of sheep in these two type-groups also increased in 1937-8. In spite of the improvements in pig prices, the receipts from this source over all farms declined by about 21 per cent in 1937-8. This decline is general for all type-groups except the Cattle and Sheep (Better Land) where a slight improvement is shown. A reduction in the number of pigs kept appears to be responsible

TABLE IV.
Receipts per Farm.

Type-Group	*Cattle and Sheep (Poor Land)*		*Cattle and Sheep (Better Land)*		*Mixed Farms*		*Dairy Farms (27—40% receipts from milk)*		*Dairy Farms (over 40% receipts from milk)*		*All Farms*	
Year	*1936–7*	*1937–8*	*1936–7*	*1937–8*	*1936–7*	*1937–8*	*1936–7*	*1937–8*	*1936–7*	*1937–8*	*1936–7*	*1937–8*
	£	£	£	£	£	£	£	£	£	£	£	£
Horses	33.1	18.7	47.2	33.7	16.0	13.0	44.0	50.4	5.6	6.2	28.8	24.2
Cattle	194.4	198.4	507.6	506.3	303.8	265.7	203.6	219.1	166.7	191.9	276.4	279.0
Butter	36.4	30.8	20.0	19.5	12.2	9.2	0.9	0.9	1.8	0.2	13.6	11.6
Milk	49.0	72.4	48.8	51.1	255.6	265.4	409.8	472.6	639.6	699.6	293.9	326.5
Cheese and Cream	3.7	3.8	—	—	2.4	2.2	—	—	1.0	0.2	1.3	
Total Dairy Produce	89.1	107.0	68.8	70.6	270.2	276.8	410.7	473.5	642.5	700.0	308.8	339.2
Sheep and Wool	202.9	157.6	374.9	385.0	148.7	158.1	130.1	117.8	96.8	92.8	191.1	183.5
Pigs	55.6	37.8	74.1	76.2	454.2	290.4	310.0	282.8	66.9	57.9	183.3	143.9
Poultry and Eggs	42.1	32.7	66.6	71.8	117.8	118.4	77.0	60.9	60.9	54.9	72.1	67.1
Total Livestock and Livestock Products	617.2	552.2	1139.2	1143.6	1310.7	112.4	1175.4	1204.5	1039.4	1103.7	1060.5	1036.9
Total Crops	3.8	6.3	11.6	11.4	37.0	46.2	37.4	67.3	40.2	32.4	26.5	32.5
Sundries	13.1	13.0	18.9	23.2	29.0	22.2	32.1	25.1	27.2	36.1	24.2	24.6
Total Receipts	634.1	571.5	1169.7	1178.2	1376.7	1190.8	1244.9	1296.9	1106.8	1172.2	1111.2	1094.0
Do. per 100 Acres	239.4	222.5	594.6	600.9	1325.5	1146.6	1049.9	1093.7	1083.9	1147.9	716.9	713.1
Produce Consumed (already included in Receipts) per farm	46.1	41.1	36.2	36.8	31.2	32.1	21.2	24.6	32.7	32.3	33.8	33.6
Do. per 100 Acres	17.4	16.0	18.4	18.7	30.0	30.9	17.8	20.8	32.0	31.7	21.5	21.7

for the change. Lower yields and some reduction in size of flocks is mainly responsible for the decline of 7 per cent in the receipts from poultry and eggs in 1937-8, while the increase in the arable land may be partly responsible for the rise in crop receipts over all farms in the latter year.

Farm Output.

The gross receipts of the farm are dependent upon the volume and price of the livestock and produce marketed, but the whole of this does not represent what the farmer has produced. The feeding of livestock often involves the purchase of store stock and a considerable proportion of the ultimate selling value is therefore represented by the price paid for them on purchase. Further, the gross sales do not take into consideration any differences in the stocks in hand at the opening and closing of the accounts. A measure of what is actually produced on the farm is, therefore, not given by a statement of all that has been sold off the farm in the course of a year. In order to arrive at what has actually been produced as a result of the farming operations, certain adjustments must be made in the items included in the gross receipts. The *farm output* is therefore calculated in the case of livestock by taking the total value of the stock in hand at the beginning of the year plus purchases and deducting from it the value of stock in hand at the end of the year and adding the value of the sales. The same method has been used in the case of crops. The available data does not permit of the further refinement of apportioning the cost of purchased foods among the different classes of livestock or the cost of seeds and artificial manures. Production as here defined is, therefore, not an exact measure of the value of what has been actually produced on the farm.

The value and proportional importance of the components of production in the sense defined above are shown for each type-group in Table V.

The average value of total output per farm rose by 2 per cent between 1936-7 and 1937-8. The output of cattle increased by nearly 5 per cent, while sheep remained very much the same in both years. There was a decline of over 7 per cent in the output of pigs and over 9 per cent in the output of poultry and eggs in 1937-8. All dairy products declined with the exception of the output of milk which rose by about 11 per cent. As regards crops the output was higher by 26 per cent in 1937-8.

Compared with 1936-7 some increase in output is evident for all type-groups except the Cattle and Sheep (Better Land) and Mixed Farms. With regard to different forms of output the data indicates a decline in the output of horses and over all farms this

TABLE V.
Farm Output per Farm.

Type-Group	*Cattle and Sheep (Poor Land)*		*Cattle and Sheep (Better Land)*		*Mixed Farms*		*Dairy Farms (27—40% receipts from milk)*		*Dairy Farms (over 40% receipts (from milk)*		*All Farms*	
Year	*1936–7*	*1937–8*	*1936–7*	*1937–8*	*1936–7*	*1937–8*	*1936–7*	*1937–8*	*1936–7*	*1937–8*	*1936–7*	*1937–8*
	£	£	£	£	£	£	£	£	£	£	£	£
Horses	18.5	18.0	34.2	17.4	12.2	4.3	33.7	20.5	11.8	10.4	22.2	14.2
Cattle	162.1	193.7	303.7	309.1	183.7	148.6	136.4	145.0	76.6	102.1	171.4	179.5
Butter	36.4	30.8	20.0	19.6	12.2	9.2	1.0	0.9	1.8	0.2	13.6	11.6
Milk	49.0	72.5	48.8	51.1	255.6	265.4	409.7	472.6	639.7	689.3	293.8	324.1
Cheese and Cream	3.7	3.7	—	—	2.4	2.2	0.1	—	1.0	0.2	1.3	1.1
Total Dairy Produce	89.1	107.0	68.8	70.7	270.2	276.8	410.8	473.5	642.5	689.7	308.7	336.8
Sheep and Wool	165.0	183.6	304.2	285.0	128.4	116.5	72.9	74.9	65.3	77.1	147.1	147.3
Pigs	52.9	38.5	62.6	76.6	257.5	203.7	276.2	271.7	56.4	56.4	136.2	126.1
Poultry and Eggs	40.7	30.7	63.2	67.2	113.6	105.5	66.7	56.8	58.2	49.4	67.7	61.4
Total Livestock and Livestock Products	528.3	571.5	836.7	826.0	965.6	855.4	996.7	1042.4	910.8	985.1	853.3	865.3
Total Crops	1.0	4.4*	13.4	20.1	33.7	36.5	45.3	66.5	25.1	30.0	23.8	30.1
Sundries	5.2	5.2	6.4	10.4	20.6	13.8	21.7	14.8	14.0	22.9	13.5	13.8
Total Output	534.5	572.3	856.5	856.5	1019.9	905.7	1063.7	1123.7	949.9	1038.0	890.6	909.2
Outper per 100 Acres	201.9	222.8	435.4	436.8	981.9	872.1	897.1	947.7	930.2	1016.5	574.5	592.6

*Minus Quality.

amounted to 36 per cent. In the case of cattle, output was generally higher in 1937-8 except on the Mixed Farms. The output of milk was higher for all type-groups and particularly in those in which this form of output is important. Other dairy products showed a general decline for all type-groups. The output of sheep and wool was lower on the Cattle and Sheep (Better Land) and on the Mixed Farms in 1937-8, but higher than in 1936-7 for the other type-groups. Output of pigs, poultry and eggs declined in all type-groups except in the case of the Cattle and Sheep (Better Land) group. The output of crops was higher for all type-groups in 1937-8 except in the case of the Cattle and Sheep (Poor Land) farms.

Expenses.

Details of the gross expenditure for each type-group are given in Table VI. The data reveals a slight decrease in total expenditure in 1937-8 over all farms and for all type-groups except the two Dairy groups. The variations in total expenditure for certain of the type-groups are, however, quite considerable, and range from a reduction of £168 per farm on the Mixed Farms to an increase of £66 on the Dairy Farms (over 40 per cent receipts from milk).

The total wages bill over all farms declined slightly in 1937-8 but in the case of the Cattle and Sheep (Better Land) and the Dairy Farms (over 40 per cent receipts from milk) they were somewhat higher in 1937-8—the increases in these type-groups being due to the higher rates of wages paid as the amount of labour employed showed some decline in 1937-8. In spite of the higher unit costs of feeding stuffs there is some curtailment of expenses on purchased foods in three of the type-groups. This is due partly to the growing of more home-grown foods and partly to the fattening of less stock. In the case of the Dairy Farms (with 27-40 per cent receipts from milk and on those with over 40 per cent receipts from this source) expenditure on feeding stuffs in 1937-8 rose by 10 and 21 per cent respectively. This was due to higher prices and heavier purchases of feeds for increased milk production. There was an increase in the quantity of purchased manures in 1937-8 and this was probably due to the concessions granted by the Land Fertility Committee as part of the national scheme for improving the productive capacity of the land. Over all farms the expenditure on fertilizers rose in 1937-8 by 11 per cent and this increase applies to all type-groups except the Dairy Farms (over 40 per cent receipts from milk) where expenses on manures were reduced by 28 per cent. Other type-groups show increases varying from 12 to 65 per cent. Some extension of the arable area together with heavy purchases of cereals and potato seed have contributed to the increase in the

TABLE VI.

Expenses per Farm.

Type-Group	*Cattle and Sheep (Poor Land)*		*Cattle and Sheep (Better Land)*		*Mixed Farms*		*Dairy Farms (27—40% receipts from milk)*		*Dairy Farms (over 40% receipts from milk)*		*All Farms*	
Year	*1936–7*	*1937–8*	*1936–7*	*1937–8*	*1936–7*	*1937–8*	*1936–7*	*1937–8*	*1936–7*	*1937–8*	*1936–7*	*1937–8*
	£	£	£	£	£	£	£	£	£	£	£	£
Rent	98.5	94.9	177.2	177.4	130.7	130.7	143.0	142.3	129.8	129.8	137.1	136.4
Rates	4.9	4.7	6.4	7.4	4.6	5.5	6.3	6.2	8.7	9.5	6.3	6.8
Wages (Hired)	77.6	76.8	183.7	193.3	126.9	127.8	115.4	110.9	165.5	164.1	137.0	137.9
Wages (Family)	75.7	62.7	72.1	70.0	51.3	44.5	27.5	28.9	28.1	35.8	50.0	48.1
Total Wages	153.3	139.5	255.8	263.3	178.2	172.3	142.9	139.8	193.6	199.9	187.0	186.0
Feeding stuffs	78.3	72.7	193.5	190.2	419.4	384.9	353.2	387.4	245.1	295.4	256.6	267.2
Manures	14.3	16.0	17.0	19.1	7.6	11.3	9.1	15.0	16.2	11.7	13.1	14.6
Seeds	8.0	12.2	10.5	16.3	10.6	11.2	9.4	16.2	8.2	6.3	9.3	12.3
Implements	5.0	41.8	20.8	11.0	41.6	24.6	53.9	28.6	50.7	34.0	35.2	27.7
Sundries	22.9	27.2	81.7	78.7	71.3	59.5	86.8	86.0	118.5	113.6	78.9	75.6
Total Direct Expenses	385.2	409.0	762.9	763.4	864.0	800.0	804.6	821.5	770.8	800.2	723.5	726.6
Horses	10.8	13.1	9.8	18.5	29.7	13.2	9.7	24.0	4.1	8.0	12.2	15.2
Cattle	54.7	36.5	252.2	209.0	126.9	121.3	81.4	112.0	103.2	139.8	126.4	127.4
Sheep	25.0	13.0	108.8	121.7	43.8	45.9	63.8	46.9	30.1	32.1	55.1	53.3
Pigs	0.6	1.9	7.4	2.7	184.6	93.0	35.9	20.1	6.5	2.9	43.3	22.1
Poultry	0.2	0.9	2.2	2.4	1.9	2.4	3.9	6.3	2.1	1.2	2.1	2.7
Total Livestock	91.3	65.4	380.4	354.3	386.9	275.8	194.7	209.3	146.0	184.0	239.1	220.7
Total Expenses	476.5	474.4	1143.3	1117.7	1250.9	1075.8	999.3	1030.8	916.8	984.2	962.6	947.3
Total Expenses per 100 Acres	179.9	184.7	581.1	570.1	1204.3	1035.8	842.8	867.4	897.9	963.8	621.0	617.5

expenditure on seeds in 1937-8. Over all farms the outlay on this form of expenditure rose by 32 per cent and this was general for all type-groups except the Dairy Farms (over 40 per cent receipts from milk) where a reduction of 24 per cent occurred. Apart from the Cattle and Sheep (Poor Land) group there has been a decline in the expenditure on implements and machinery and over all farms such costs were reduced by 21 per cent in 1937-8. More horses were bought in 1937-8 and expenditures on horses were higher for all type-groups except the Mixed Farms. For all farms taken together expenditure on cattle was slightly higher in 1937-8, but reductions were recorded in all type-groups with the exception of the two Dairy groups. On those with 27-40 per cent receipts from milk expenditure on cattle was 37 per cent heavier in that year and 35 per cent heavier on those with over 40 per cent receipts from milk. There was a drop in expenditure on sheep in the Cattle and Sheep (Poor Land) and in the Dairy group (27-40 per cent receipts from milk) while in the other type-groups expenses were higher than in 1936-7. Over all farms there was a decline of just over 3 per cent in purchases of sheep in 1937-8. There was a considerable reduction in the purchases of pigs in 1937-8 and over all farms expenses dropped by nearly 49 per cent. Only in one group—Cattle and Sheep (Poor Land)—did expenditure on pigs rise in 1937-8 and in this case the purchases represented but a small item. Expenditure on pigs are of far greater importance on the Mixed Farms than on any of the other type-groups. In 1937-8 the outlay on this class of livestock on the Mixed Farms only averaged £93 per farm as compared with £185 per farm in the previous year. Over all farms there was a rise of over 25 per cent in expenditure on poultry in 1937-8 and this increase was common to all type-groups except the Dairy Farms (over 40 per cent receipts from milk) which showed a decrease in expenditure on poultry stocks.

Financial Results.

The farmers' profit (Farm Income) in 1936-7 and 1937-8 for each of the type-groups is given in Table VII. The profit as here defined is the margin between gross receipts and gross expenditure together with any increase or decrease that has occurred in farm valuations. Expenditure on wages includes the reward for family labour other than that of the farmer and his wife. The rates charged for family labour are in every case those which would have been paid on the basis of the time worked for comparable labour if hired. The amount charged to hired labour includes the value of produce allowed to workers as perquisites and of cottage accommodation or board given in lieu of cash wages. The receipts include the value of farm produce consumed in the house on the basis of quantities and prices realisable by sale of similar produce. The value of the farm house at rateable value is also included in the receipts. In the case of farms occupied by owners the rent is assessed by the Department after consultation with the farmers concerned—account being taken of rents of similar tenant farms in the neighbourhood. The profit as stated must therefore be taken to represent the reward of the occupier (the farmer and his wife) for work and management and also for the use of the capital which is invested in the farm.

TABLE VII.

Farm Income in £'s per Farm.

Year.	*Receipts.*	*Expenses.*	*Cash Balance.*	*Valuation Difference.*	*Farm Income.*
	£	£	£	£	£
	Cattle and Sheep (Poor Land).				
1936–7	634	476	158	— 4	154
1937–8	571	474	97	+ 101	198
	Cattle and Sheep (Better Land).				
1936–7	1170	1143	27	+ 81	108
1937–8	1178	1118	60	+ 33	93
	Mixed Farms.				
1936–7	1377	1251	126	+ 50	176
1937–8	1191	1076	115	— 4	111
	Dairy Farms (27-40% *Receipts from Milk*).				
1936–7	1245	999	246	+ 42	288
1937–8	1297	1031	266	+ 55	321
	Dairy Farms (over 40% *Receipts from Milk*).				
1936–7	1107	917	190	+ 25	215
1937–8	1172	984	188	+ 75	263
	All Farms.				
1936–7	1111	963	148	+ 40	188
1937–8	1094	947	147	+ 53	200

The balance of receipts over expenses over all farms is very similar in both years and averaged £148 in 1936-7 and £147 per farm in 1937-8. When, however, valuation differences are taken into consideration there is some improvement in the returns in 1937-8—the average " farm income " being £188 in 1936-7 and £200 per farm in 1937-8. On three of the type-groups the " cash balance " declined in 1937-8 and varied from a decline of £2 on the Dairy Farms (over 40 per cent receipts from milk) to £61 per farm on the Cattle and Sheep (Poor Land) group. An improvement is shown in the " cash balance " of £33 per farm in the Cattle and Sheep (Better Land) group and of £20 per farm on the Dairy Farms

(27-40 per cent receipts from milk) in the latter year. Farm Income was higher in 1937-8 in all type-groups with the exception of the Cattle and Sheep (Better Land) group and the Mixed Farms which showed reductions of £15 and £65 respectively. In the other type-groups the increases ranged from £23 per farm on the Dairy Farms (27-40 per cent receipts from milk) to £48 on the Dairy Farms (over 40 per cent receipts from milk).

The number of profits and losses for each type-group is given in Table VIII.

TABLE VIII.

Profit and Losses by Type-Group.

Type-Group	*1936–7*			*1937–8*		
	Losses	*Profits*	*Total*	*Losses*	*Profits*	*Total*
Cattle & Sheep (Poor Land)	1	9	10	1	9	10
Cattle & Sheep (Better Land)	3	9	12	4	8	12
Mixed Farms	2	8	10	3	7	10
Dairy Farms (27—40% receipts from Milk)	0	11	11	0	11	11
Dairy Farms (over 40% receipts from Milk)	2	11	13	0	13	13
All Farms	8	48	56	8	48	56

Over all farms the positions remain unchanged regarding the numbers of farms showing profits and losses in the two years and there is but very little change in the position so far as the type-groups are concerned. There has, however, been some alteration in the frequency distribution of " farm incomes." Compared with 1936-7 fewer farms showed small profits of under £100, a higher number showed profits of between £100—£500, while the same number of farms showed profits of between £500 and £700 in both years. There were no farms showing losses of over £300 in 1936-7 and of the eight which had unfavourable returns, seven had losses of under £100. **In 1937-8 fewer farms made losses of under £100 and two out of the eight farms showed losses exceeding £300. (See Table IX.) Of the 56 farms in the total sample, 31 showed a higher " farm income " in 1937-8 than in the previous year.**

TABLE IX.

Frequency Distribution of Profits (Farm Income).

	Profits		*Losses*	
	Number of Farms		*Number of Farms*	
	1936–7	*1937–8*	*1936–7*	*1937–8*
	No.	*No.*	*No.*	*No.*
Profits or Losses (Range)				
Under £100	15	10	7	5
£101—£300	19	22	1	1
£301—£500	7	9	0	2
£501—£700	7	7	0	0
Total Farms	48	48	8	8

The position for all farms and for the different type-groups is given in Table X.

TABLE X.

Increase or Decrease in average "Farm Income" in 1937-8 compared with 1936-7.

Type-Group	*Number of Farms*	*Increase or Decrease in Average Farm Income*	*Number of Farms faring*	
			Worse	*Better*
		£		
Cattle and Sheep (Poor Land)	10	+44	3	7
Cattle and Sheep (Better Land)	12	—15	7	5
Mixed Farms	10	—65	7	3
Dairy Farms (27—40% Receipts from Milk)	11	+23	3	8
Dairy Farms (over 40% Receipts from Milk)	13	+48	5	8
All Farms	56	+12	25	31

On balance the Cattle and Sheep (Poor Land) and the two Dairy groups have fared better while the Cattle and Sheep (Better Land) and particularly the Mixed Farms have fared worse. In addition to the "farm income" the sums allowed for occupiers' wages and interest on capital are given in Table XI and the results are shown on a further basis of "labour income" and "managerial earnings." The "farm income" represents the balance remaining after deducting from "gross income" wages of family labour other

TABLE XI.

Farm Income, Labour Income and Managerial Earnings in £'s per Farm.

Type-Group	*Farm Income*		*Interest on Capital at 6 per cent.*		*Labour Income*		*Allowances for Wages to Farmer and Wife*		*Managerial Earnings*	
Year	*1936–7*	*1937–8*	*1936–7*	*1937–8*	*1936–7*	*1937–8*	*1936–7*	*1937–8*	*1936–7*	*1937–8*
	£	£	£	£	£	£	£	£	£	£
Cattle and Sheep (Poor Land)	154	198	63	65	91	133	68	72	23	61
Cattle and Sheep (Better Land)	108	93	87	90	21	3	48	59	27*	56*
Mixed Farms	176	111	76	77	100	34	73	67	27	33*
Dairy Farms (27—40% receipts from Milk)	288	321	76	79	212	242	72	72	140	170
Dairy Farms (over 40% receipts from Milk)	215	263	69	72	146	191	51	54	95	137
All Farms	188	200	74	77	114	123	65	68	49	55

*Minus Qualities.

than that of the farmer and his wife. The " labour income " is calculated by deducting from the " farm income " an interest charge on the capital invested at 6 per cent. The " managerial earnings " is the sum left over by deducting from the " labour income " wages to the farmer and his wife for manual labour. The basis adopted for wages is to assess the full-time manual labour of an occupier at £90 per annum and a wife at £52 per annum.

When interest is allowed on the capital invested at 6 per cent per annum, the " labour income " over all farms averaged 43s. 10d. per week in 1936-7, and 47s. 4d. in 1937-8. The results also indicate an improvement in the " labour income " in 1937-8 for all type-groups except the Cattle and Sheep (Better Land) and the Mixed Farms. The " labour income " in the Cattle and Sheep (Poor Land) group was 35s. 8d. per week in 1936-7 and 51s. 2d. per week in 1937-8. On the Dairy Farms (27-40 pre cent receipts from milk) it averaged 81s. 6d. per week in 1936-7 and 93s. 1d. per week in 1937-8 and on the Dairy Farms (over 40 per cent receipts from milk) the " labour income " averaged 56s. 2d. per week in 1936-7 and 73s. 5d. in 1937-8. In the case of the Cattle and Sheep (Better Land) group the " labour income " averaged 8s. 1d. per week in 1936-7, but only averaged £3 *per farm* in 1937-8, while on the Mixed Farms the decline in " labour income " was from 38s. 5d. per week in 1936-7 to 13s. 1d. in 1937-8.

Over all farms the average " managerial earnings " were 18s. 10d. per week in 1936-7 and 21s. 2d. in 1937-8. The situation varied, however, between one type-group and another. The position was least satisfactory in the Cattle and Sheep (Better Land) group where the " managerial earnings " failed by £27 per farm in 1936-7 and by £56 per farm in 1937-8 to meet the cost of wages to the farmer and/or his wife at the rate of £90 and £52 per annum respectively for actual time engaged in manual labour. There was also a deficit of £33 per farm in 1937-8 on the Mixed Farms, but in 1936-7 there was a surplus of £27 per farm or 10s. 5d. per week. The Cattle and Sheep (Poor Land) group showed an improvement in " managerial earnings " of from 8s. 10d. per week in 1936-7 to 23s. 4d. per week in 1937-8, and the Dairy Farms (27-40 per cent receipts from milk) from 53s. 10d. per week in 1936-7 to 65s. 4d. per week in 1937-8. On the Dairy Farms (over 40 per cent receipts from milk) the " managerial earnings " increased from 36s. 6d. per week in 1936-7 to 52s. 8d. per week in 1937-8.

Measured by any of these tests, viz., " farm income," " labour income," and " managerial earnings," per farm, the results indicate some improvement in returns for the two Dairy groups and for the Cattle and Sheep (Poor Land) group and also over all farms. Some decline is, however, noticeable in the returns for the Cattle and Sheep (Better Land) and the Mixed Farms.

Although the average " farm income " obtained in 1937-8 for the recorded farms was somewhat better than in the previous year, the improvement, as previously stated, was not general for all the type-groups. The reasons for the changes in the profits within the type-groups are complex. The decline in profits on the Mixed Farms is mainly accounted for by the reduction in income from cattle and pigs coupled with some decline in the valuation. The decline in profits in the Cattle and Sheep (Better Land) group appears to be due to the smaller increase in valuation in 1937-8 as the " cash balance " is higher than in 1936-7. The improvement in the Cattle and Sheep (Poor Land) group can be largely attributed to the increase in valuation as gross receipts were about 10 per cent lower than in 1936-7 while gross expenditure remained about the same in both years. On the two Dairy groups the improvement in profits appears to be the result of the increase in income from milk, together with larger increases in valuation.

TABLE XII.

Index Numbers for Crop Years.*
Base 1911—13 = 100.

	Crop Years (September to August)	
	1936–7	*1937–8*
Commodity :		
General Index	130	130
General Index (including Subsidies)	134	135
Fat Cattle	103	114
Fat Cattle (including Subsidy)	118	129
Store Cattle	106	114
Dairy Cows	111	119
Fat Sheep	141	119
Store Sheep	127	109
Bacon Pigs	119	126
Pork Pigs	120	130
Store Pigs	139	152
Poultry	121	129
Eggs	121	131
Milk	176	189
Butter	102	113
Cheese	112	128
Wool	127	112
Wheat	120	107
Wheat (inc. Subsidy)	130	130
Barley	126	146
Oats	113	117
Potatoes	186	146
Hay	100	82
Feeding Stuffs	114	119
Fertilizers	90	93

*From the Ministry of Agriculture and Fisheries, Agricultural Market Reports.

There have been some changes in the amount and composition of total income and expenditure. Over all farms the income from milk increased in 1937-8 and receipts from other dairy products declined. Income from cattle stands at about the same level in both years, but receipts from all classes of livestock were lower than in 1936-7. Sales of crops were higher in 1937-8. Expenditure on purchases of livestock and implements were lower while expenses incurred on purchases of feeding stuffs and manures increased in 1937-8. Wages paid remained practically the same in both years. For all farms taken together the total receipts fell by about 2 per cent in 1937-8 and gross expenditure showed a similar decline.

CHANGES IN PRICES OF EGGS DURING THE PERIOD 1925-1938.

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With the general improvement in prices of eggs and some reduction in costs of feeding stuffs there is every encouragement for farmers to increase the size of their poultry enterprises. The lack of confidence in recent years has caused a decline in the number of poultry, but an examination of the records of some enterprises shows that even in 1933, 1934, and 1935, when prices of eggs were at their lowest level, reasonable profits were obtained from well managed flocks free from disease. The evidence shows that the confidence of those who maintained the size of their flocks during these difficult years was justified.

The poultry industry is an important one and in 1936-7 the value of eggs and poultry produced in Great Britain amounted to £21.4 million or to 10 per cent of the total value of all agricultural and horticultural output. It must be admitted, however, that despite the considerable increase in the numbers of poultry during the years following 1924 there is still room for further expansion. At the present time home production of eggs accounts for only 55 per cent of total supplies. In Wales there is a particular need for expansion since the sparseness of poultry in some districts is one of the reasons for the poor market conditions. The inclusion of good commercial flocks in any farming system adds to its economic stability. Smallholders in particular would be well advised to treat poultry-keeping as one of the important enterprises, for their potential standard of living may be largely dependent upon their capacity to develop intensive enterprises.

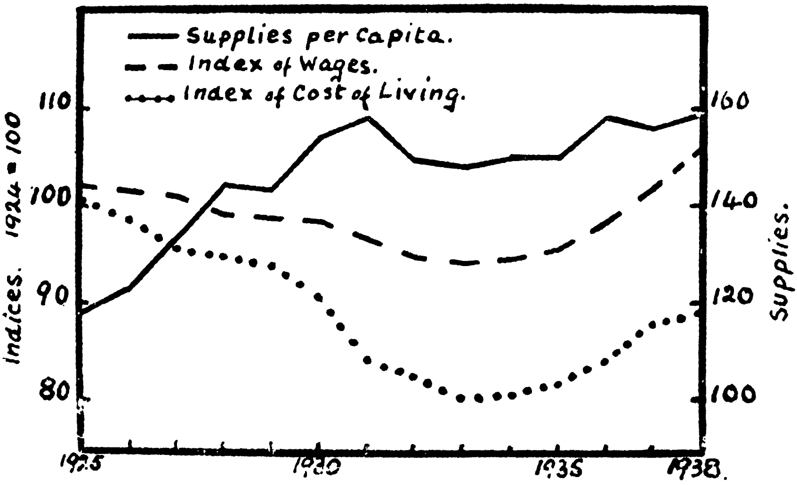
In 1938 the average value of first and second quality eggs sold at town and country markets in England and Wales was 15s. 4d. per 120 eggs, which was 24 per cent below that obtained in 1925. This decline was partly in sympathy with the downward movement in the general price level. The level of wholesale prices in 1925 was 59 per cent higher than in 1914, but by 1932 it was only one per cent above the pre-War level. During the last five years, however, there has been a general improvement in all prices, including those of eggs.

Although eggs belong to the group of protective human foodstuffs, the consumption of which is vital for the maintenance of health and efficiency, yet, owing to their very high prices during the autumn and winter seasons, they are commonly considered as luxuries by consumers. Nevertheless, consumers do appreciate the importance of eggs in the dietary and reductions in prices or improvements in the purchasing power of consumers are reflected in increases in the consumption of eggs. In considering changes in the general standard of living of consumers three conditions must be borne in mind, namely, changes in weekly cash wages, changes in the incidence of risk of unemployment, and changes in the general level of retail prices or cost of living.

In the three years 1925 to 1927 inclusive, the general level of weekly cash wages was from one to two per cent above that for 1924. During the subsequent six years there was a steady fall

CHART I.

Wages, Cost of Living and Consumption of Eggs.



in wages, but wholesale prices also fell during this period. In 1933 wages were at their lowest level since 1924 when they had declined by six per cent. From 1934 onwards cash wages have steadily improved and at present are six per cent higher than in 1924 and are in fact higher than at any time since that year.

But while wages did not fall very much during the depression years there did occur an appreciable increase in unemployment. The continued decline in wholesale prices caused increasing financial difficulties in industry and unemployment increased from between 10 and 11 per cent of the insurable population in the years 1920-2 to over 22 per cent in 1932. In recent years there has been an important reduction in unemployment and at the present time (January, 1939) 13.8 per cent are unemployed. Since the unemployment payments are less than normal weekly wages, the general decline in weekly cash incomes is greater than that indicated by the index of weekly wage-rates.

The cost of living declined by 20 per cent during the period 1925 to 1933 and although some increase has occurred since, it still remains at about 11 per cent lower than in 1925. Thus it may be true to say that standards of living of the workers at the present time are higher than at any time during the period under review. Present conditions, however, are by no means satisfactory and during the depression years there was serious limitation in the ability to purchase normal requirements.

Supplies of Eggs.

The factors considered above, though of considerable importance to the prosperity of the poultry industry, are external and outside the direct control of poultrymen. But farmers have been in a position to control the home supplies of eggs and the post-war history of the industry is one of almost continuous expansion. In 1926 the number of fowls recorded on holdings exceeding one acre in extent, in England and Wales, was 36,586,000 while in 1938 the number was 52,439,000. This increase continued steadily between 1926 and 1934, but in subsequent years there has existed some feeling of uncertainty causing restriction of hatching and rearing. In 1926 there were 142 fowls per 100 acres of crops and grass in England and Wales and by 1934 the density had increased to 245. Information collected in June, 1938, shows that the number of fowls over six months old was 6.5 per cent less than in the previous year, while those under six months increased by 4.1 per cent, and the total fowls numbered 212 per 100 acres.

In Wales the number of poultry per 100 acres of cultivated area and the rate of increase have remained much lower than in England.

Poultrymen in the Principality are at some disadvantage in the development of poultry farming. A large proportion of the total land area is situated at high elevations and many areas are too wet and cold for successful poultry farming. Many areas still lack an efficient marketing organisation and the necessity of transporting poultry produce to English consuming centres reduces the returns obtained by farmers.

But in all districts of England and Wales some increase has occurred and near large residential areas or seaside resorts the development has been very great. Alongside this increase in numbers there has been an important improvement in the productivity of laying flocks. The class of bird maintained on many general farms and on specialist farms is good, and gives annual yields from 140 to 160 eggs per bird. Records collected from some flocks in Wales show that during the last five years the average yield for all flocks has varied between 132 and 149 eggs.

Total home production of eggs amounted to 2,708 millions in 1925 and in the next nine years increased by nearly 76 per cent to 4,764 millions. In recent years home supplies have declined in quantity and in 1937 amounted to approximately 4,404 millions. Imported supplies increased from 2,602 millions in 1925 to 3,172 millions in 1930. During the next three years supplies from abroad fell, but some increases have occured in recent years, and in 1938 total imports amounted to 3,324 millions, which was about 12 per cent above those for the previous year. Much more important are the changes which have occurred since 1924 in the supplies per head of the population. During the seven years, 1925-31, the per capita supplies increased from 118 to 158 eggs and for the last seven years have fluctuated between 148 and 159 eggs. The competitive power of imported eggs depends to a great extent on their source of origin. Supplies from Denmark and Eire are the most popular after those produced at home. In 1937 the former country was responsible for 40 per cent of the imported supplies, Eire accounted for a further eight per cent, and the Netherlands, Poland, Australia and China accounted for nine, seventeen, five and four per cent of the total imports respectively.

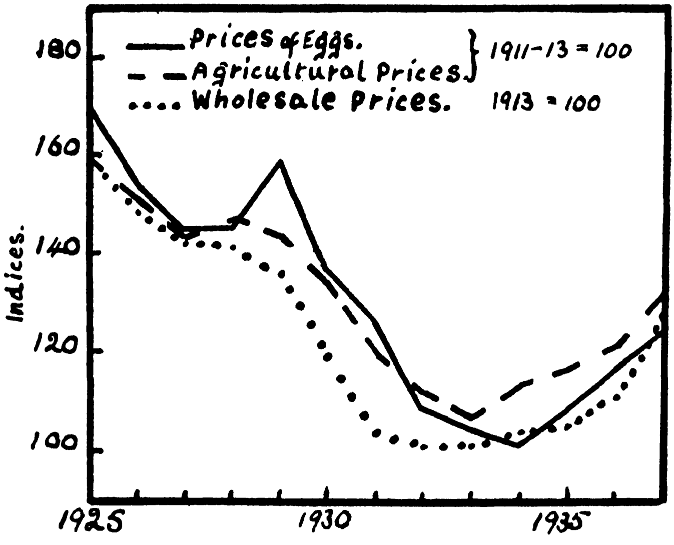
A characteristic feature of the home supply is the seasonality of production. Records for some Welsh farms show that during the month of November production varies between 2 and 6 per cent while in March and April it varies between 9 and 14 per cent of the total for the year. The bulk of the imported supplies come from countries where production follows the same seasonal trend as in this country. But the monthly imports from many of these countries are remarkably stable. In fact the total monthly imports in 1937 varied between 5.2 per cent of the yearly total in February and 9.3 per cent in December. Denmark achieves some uniformity in her monthly supplies by placing large quantities of eggs in cold storage and also by preserving large quantities during the months of heavy production, and many of these are exported to this country during the winter when prices are high.

General Price Movements.

The high degree of appreciation for eggs on the part of consumers was an important factor in the maintenance of prices during the period under review. Total supplies increased by 29 per cent during the years 1925 to 1932 and during this period their relative value remained higher than that for all agricultural products. The relative value of eggs declined from 65 to 2 per cent above the 1911-3 level during the period 1925-34. In the period of increasing prices from 1934 onward, improvements in the prices of eggs have been less than those for most agricultural products.

CHART 2.

Changes in Price of Eggs, of All Agricultural Products, and in Wholesale Prices.



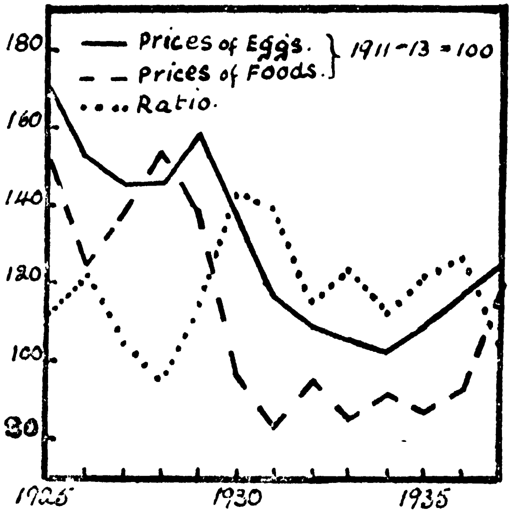
Poultrymen were fortunate in being able to purchase feeding stuffs at a relatively low cost during the early years of the present decade. At the beginning of the period feeding stuffs were about 52 per cent above their 1911-3 level. For the five years 1925 to 1929 inclusive, costs of feeding stuffs fluctuated from 24 to 54 per cent above the pre-War level. These erratic fluctuations were followed by a sharp fall in prices and during the seven years ending

1936 prices remained below those prevailing in 1911-3 and in 1931 were 17 per cent below that level.

With receipts from the sale of eggs forming from 70 to 80 per cent of the total returns from poultry and costs of foods accounting for from 60 to 70 per cent of the total cost, the relative movements in the prices of these two commodities are of considerable importance to poultrymen. Chart 3 shows these price movements and, what is really important, the ratio of the prices of eggs to the costs of feeding stuffs.

CHART 3.

Relationship between Prices of Eggs and Cost of Foods.



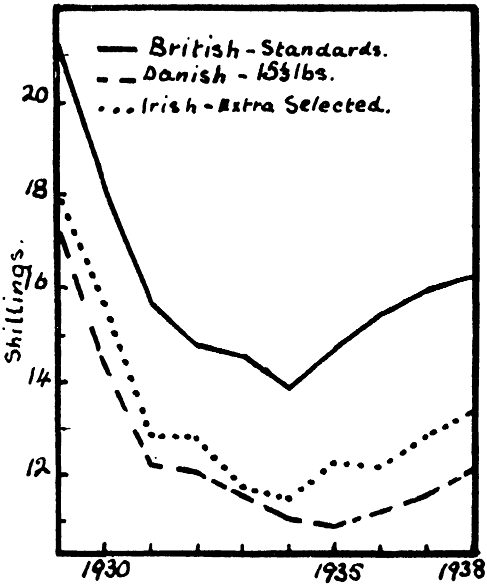
The information collected from some poultry enterprises in Wales shows that in each of the last five years the market value of 120 eggs has been equal to the cost of from 1.3 to 1.5 cwt. of mixed poultry feed. Recent fluctuations in the profitableness of individual enterprises have been due largely to the incidence of diseases while the combined influences of changes in the value of eggs and in the cost of foods have been less important.

Prices of Home Produced and Imported Eggs.

Home produced eggs are preferred by consumers and command the higher prices. Irish eggs are second in the scale of preferences, but even so their market value is about two shillings per long hundred below that of the home product. Danish, Dutch and Belgian eggs command slightly lower prices than those paid for imports from Eire and Northern Ireland. The decline since 1928 in the prices of those imported eggs held in higher favour by consumers is of approximately the same importance as that registered for eggs produced at home. Market values within the different countries fell by anything from 40 to 60 per cent during the seven years 1928 to 1934. The decline in the level of prices was greatest in these countries having difficulties in finding adequate outlets for supplies not required for home consumption. The general information shows that the decline in prices of eggs in this country during the early years of the present decade was part of the fall in general prices.

CHART 4.

Value of Home Produced and of Imported Eggs.
Per 120 Eggs.



Between 1929 and 1933 the market value of National Mark Standard weight eggs declined from 21s. 2d. to 13s 11d. per long hundred and in the next four years increased by 2s. 4d. Irish eggs (Selected) declined from 16s. 9d. to 11s. 2d. per 120 during the seven years ending 1934 and then increased to 13s. 4d. in the following four years. Danish eggs of the grade 15½ lbs. per 120 fell from 16s. 2d. per 120 to 10s. 3d. in the five years 1928-32, but by 1938 they had increased to 12s. 2d. The margin between the monthly average prices of home produced eggs and prices of comparable imported grades is widest during the period of rising prices from May to November. In May, 1937, there was a difference of 2s. 3d. per 120 between the prices of National Mark Standards and Danish (15½ lbs. per 120), but by November it had increased to 8s. 3d.

Irish Extra Selected were also 2s. 3d. per 120 eggs below the value of the National Mark Standards in April and in this case the margin increased to 4s. 7d. in November.

Farm Prices.

The prices realised for eggs from individual farms is influenced by three main circumstances, namely, the seasonality of production, the size and quality of the eggs produced and lastly the methods of marketing. In each year the extreme range of variation between the highest and lowest prices is between 6d. and 7d. per dozen eggs but the usual range of difference amounts to about 3d.

TABLE I.

Yearly Average Farm Prices of Eggs.

Range in pence per dozen.	*Number of Cases.*				
	1933–4	*1934–5*	*1935–6*	*1936–7*	*1937–8*
Under 12	8	5	1	—	—
12 and under 13	6	3	2	2	—
13 ,, ,, 14	3	7	7	4	—
14 ,, ,, 15	5	6	14	7	5
15 ,, ,, 16	3	2	9	15	9
16 ,, ,, 17	1	—	3	8	7
17 ,, ,, 18	1	—	3	5	11
18 ,, ,, 19	—	—	1	3	8
19 ,, ,, 20	—	—	—	1	4
20 ,, over	—	—	—	2	5
Total	27	23	40	47	49
	d.	d.	d.	d.	d.
Average	13.75	13.75	14.75	15.50	17.25

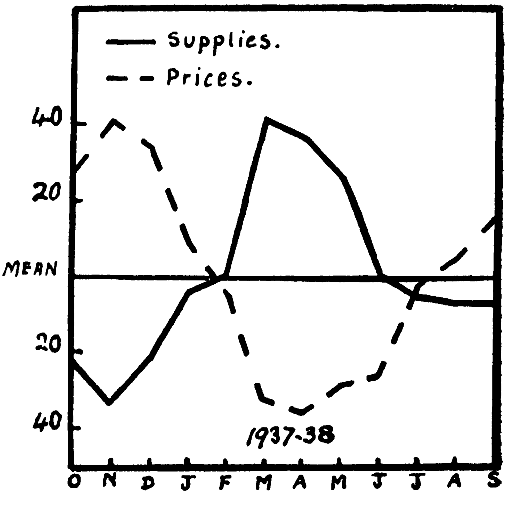
The highest prices are obtained by farmers selling part or the whole of their supplies direct to consumers or to retailers. But most of the farmers sell their eggs to grading stations or to dealers and the prices which they obtain show only small differences. A few owners of small flocks situated in remote districts are almost wholly dependent upon village shop-keepers for the disposal of their eggs and obtain the lowest prices. The average of the farm prices recorded in the two years 1933-4 and 1934-5 was 13.75d. per dozen and in the next three years it had increased by 3.5d. per dozen. Assuming an average yield of twelve dozen eggs per bird this increase in the value of eggs amounts to 3s. 6d. per bird.

The average of the monthly prices realised on the farms for which information is available was lower than that reported from representative country markets in Wales. Divergencies between farm prices and market quotations are widest in the late autumn when prices are rising to their seasonal high level. Occasionally farm prices in the spring exceed those recorded for representative markets. In each of the last four years the means of the monthly farm prices have been from 0.31d. to 0.82d. per dozen below the means of the quoted prices at representative Welsh markets. These latter prices refer to eggs sold in semi-retail markets and the producer has to bear the cost of transporting the eggs to such markets. The prices on the recorded farms are those obtained, firstly, from dealers who collect the eggs at the farms, the farmer having no direct marketing costs to meet ; secondly, those prices paid to producers by owners of grading stations who usually collect the eggs from the farms and thirdly, prices realised by sales directly to retailers, shopkeepers, etc. The average of all farm prices is higher than that paid by the owners of grading stations and last year the mean of the monthly prices obtained by a group of farmers selling to grading stations was 0.67d. per dozen below the mean of the monthly farm prices and more than 1d. below the mean of the prices quoted for Welsh markets. It must be emphasised, however, that the sample includes quite a number of cases where eggs are sold to retailers and in the semi-retail market and the prices paid by owners of grading stations are usually better than those paid by dealers.

CHART 5.

Relationship between Supplies and Prices of Eggs.

Percentage Deviation from the Mean.



The records of production for some farms in Wales show important differences in the seasonality of production. Some flocks on general farms fail to produce more than two per cent of their yearly total during November while the better managed flocks will give six or seven per cent of their yearly total during that month. Monthly production for all farms varied from 5.5 per cent of the yearly total in November to 11.7 per cent in March. In some cases where the laying flocks are very small the bulk of the production during the winter months is consumed in the farmhouses.

The relationship between monthly production and the prices of eggs is shown in Chart 5. In 1937-8 the monthly production from the recorded flocks varied from 34 per cent below the monthly mean in November to 40 per cent above that mean in March.

Production in eight of the twelve months was below the monthly mean. In the three months March, April and May, production was well above and in the three months October, November and December well below, the mean.

The average prices in six months were above, and those for the other months below, the mean price for the year. In November the prices were 40 per cent above, while in April they were 36 per cent below, the mean of the monthly prices.

The Influences of Seasonality of Production, of Grade and of Quality upon yearly prices.

The average annual prices obtained for eggs sold to grading stations is affected by seasonality of production and also by the grade and quality of the eggs. There is a considerable range of variation in the proportion of each farmer's eggs placed in the different grades as is indicated by the following results for eggs sold during 1937-8.

TABLE II.

Grading Results.
(Per cent of Total Eggs sold to Grading Stations).

Farm No.	*Specials.*	*Standards*	*Mediums.*	*Other Grades.*
1	57.55	31.24	5.79	5.42
2	48.96	41.69	5.80	3.55
3	36.43	40.00	16.37	7.20
4	36.05	46.25	9.50	8.20
5	31.45	47.07	15.61	5.87
6	29.72	43.23	16.55	10.50
7	25.04	53.36	15.10	6.50
All Farms	40.90	42.65	10.41	6.04

The proportion of specials sold from each of these farms varied between 25 and 57 per cent and in nearly every case specials and standards represented more than 75 per cent of the total eggs sold. The most important factors accounting for differences in the recorded grading results were (a) the size of the laying flock and (b) the proportion of pullets in the laying flocks. Owners of small flocks are often in a position to use all the lower grade or small eggs in the farmhouse. In the two cases where the proportions of special were below 30 per cent. the farmers were increasing the size of their enterprises and had a large number of pullets in the laying flocks.

Monthly grading results show that the proportions placed in the two grades, specials and standards, are highest in the spring and lowest in the autumn when pullets are coming into lay. The combined results show that pullet eggs ranged from 7 to 9 per cent of all eggs sold in each of the three months July to September. The number placed in the medium grade varied from 3 per cent in March to 23 per cent in September.

Information from eight farmers selling their eggs to the same grading station during 1935 showed that there was a difference of 1.1d. per dozen eggs between the highest and lowest yearly average prices. Similar information obtained during 1937-8 from seven farmers selling to three different grading stations shows that the difference between the highest and lowest average prices was 3.1d. Taking 15d. per dozen as a standard value for comparison in 1935 the actual values were from 1.64d. to 2.74d. below that standard.

TABLE III.

Causes of Differences in Prices of Eggs in 1935.

Farm No.	*Actual Prices.*	*Difference between Standard and Actual Prices*	*Differences due to :—* *Size and Quality.*	*Seasonality of Production.*
	d.	*d.*	*d.*	*d.*
1	13.36	1.64	0.91	0.73
2	13.31	1.69	0.66	1.03
3	13.10	1.90	0.64	1.26
4	12.68	2.32	0.38	1.94
5	12.50	2.50	0.27	2.23
6	12.48	2.52	0.55	1.97
7	12.36	2.64	0.58	2.06
8	12.26	2.74	0.66	2.08

Winter production on Farm No. 1 was much better than that on any of the other farms but size and quality were not so good. On Farm No. 5 size and quality of the eggs were good but winter production was very much below the standard. The individual results show that unfavourable seasonal production was the most important factor causing differences between actual and standard prices and in the very worst cases the returns would have been about

2s. per bird higher if the seasonality of production had been even throughout the year. Losses due to the size and quality of egg being below those for the standard were from 3d. to 10d per bird.

Information relating to eggs sold during 1937-8 to grading stations operating in different parts of Wales shows that differences in the weekly prices paid for eggs of the same grade were partly responsible for the variations in the net farm prices.

TABLE IV.

Causes of Differences in Value of Eggs in 1937-8.

Farm Number.	*1*	*2*	*3*	*4*	*5*	*6*	*7*
	d.	*d.*	*d.*	*d.*	*d.*	*d.*	*d.*
Actual Prices per dozen.	18.43	16.48	15.34	15.52	16.59	16.63	16.39
Difference between standard and actual prices :							
Above	0.77	—	—	—	—	—	—
Below	—	1.18	2.32	2.14	1.07	1.03	1.27
Difference due to —							
(*a*) seasonality of supplies	—0.82	—1.01	—1.89	—1.64	—0.98	—0.55	—0.29
(*b*) size and quality	+0.30	+0.20	—0.12	—0.18	—0.15	—0.33	—0.23
(*c*) collecting charges	—	—0.14	—0.25	—0.25	—0.02	—	—
(*d*) Prices paid for similar grades	+1.29	—0.23	—0.06	—0.07	+0.08	—0.15	—0.75

In no instance did the charges for collection amount to more than a farthing per dozen eggs. The eggs from Farm No. 1 were sold to a station paying very good prices while low prices were paid for those from Farm No. 7. Eggs from Farms No. 1 and 2 were above the average for size and quality while these from Farms No. 6 and 7 were small in size. It is worth noting that although eggs from Farms No. 3 and 4 were better than those from Farms No. 6 and 7 their average prices were 1d. per dozen lower. The average prices of eggs sold from Farms No. 3 and 4 were 2.14d. and 2.32d. per dozen respectively below the average for the whole group while the average price of eggs from Farm No. 1 was 0.77d. above the average for the group. On no farm was the monthly production even throughout the year but on Farm No. 7 the loss due to uneven monthly production was only 0.29d per dozen. In contrast the prices of eggs sold from Farms No. 3 and 4 would have been 1.89d. and 1.64d. per dozen higher if monthly production had been uniform. The high annual average price received by Farm No. 1 was due chiefly to the better prices obtained and to a lesser extent to the good size and quality of eggs produced.

Conclusions.

There is need for some improvement in the methods of marketing in many districts in Wales and one of the obstacles to any improvement is the small number of fowls found in some areas. The collection and marketing of eggs from small scattered flocks is costly and the establishment of more assembling points with the essential equipment for collecting and grading will not be undertaken until promoters can be assured of a reasonable supply of eggs. But with the improved marketing arrangements variations in the average prices received by individual poultrymen will remain. Farmers situated long distances from consuming centres will have to bear higher costs of transport and will not have the advantage of selling any appreciable quantity of eggs direct to consumers.

It is important that the class of bird maintained should produce high grade eggs and the general information indicates that many flocks are now producing eggs of good size and quality. Better returns could be obtained by increased winter production. There are cases where higher production can be obtained by better management of the birds during the last three months of the year. In many instances pullets do not come into lay until late October and a large proportion of the eggs are small. Where production during November is as low as two per cent of the yearly total there should be no great difficulty in obtaining appreciable improvements which would increase the yearly average prices.

The market prices of eggs have been steadily improving during the last four years and the general indications are that the present level will continue, providing that the purchasing power of the working classes is maintained. Other essential foodstuffs such as the cereals and meatstuffs have a stronger hold upon consumers and their prices are not influenced to the same extent by changes in the general economic conditions.

With any improvement in the prices of eggs there will be additional inducement for foreign countries to export larger quantities to this country. Until there occurs a considerable increase in the numbers of fowls in this country we must remain dependent upon other countries for a large part of our supplies and in any case consumers with very small incomes do not purchase home produced eggs except in the spring when prices are very low. Any restriction of imported supplies would have little influence in increasing the consumption of home produced eggs by these classes.

It is recognised that the present uncontrolled methods of marketing are uneconomic and under the proposed Poultry Industry Bill it is hoped to remedy some of the defects. Two of the difficulties at the present time are the lack of adequate cold storage facilities and absence of any proper control over the flow of imports. The industry requires more uniform prices throughout the year and these cannot be obtained unless the flow of eggs into the consumers' market is regulated. An increase in the cold storage capacity, an efficient system of control of imports and the orderly marketing of the home product will do much to minimise the seasonal fluctuations in prices and thus encourage an increased consumption of eggs.

SUPPLIES AND PRICES OF SOME GREEN VEGETABLES.

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Wales is a deficiency area as regards the supply of green vegetables and a large part of consumers' requirements have to be imported from English producing areas. This is unfortunate, especially as it is the opinion of many now actively engaged in the cultivation of these crops in the Principality that there are districts where soil and climatic conditions are well suited to market gardening and horticulture. In each of the last seven cropping years the total value of vegetables produced in England and Wales has varied between £12.3 and £16.8 millions. The value of these crops has ranged from 6.1 to 8.4 per cent of the total value of all agricultural and horticultural output. Separate information relating to the value of the production in Wales is not available but information relating to the acreage under vegetable crops in June 1937 shows that less than one per cent of the cultivated area (total agricultural land area less rough grazings) was utilised for vegetables crops. Vegetable crops excluding potatoes accounted for only 0.14 per cent. In England 3.5 per cent of the cultivated area was used for the production of vegetables, and 1.5 per cent for the production of vegetables other than potatoes. The total area under all vegetables in England amounts to 9 per cent of the arable area as compared with 3.7 per cent in Wales.

The production of green vegetables for canning is not very important in Wales. One very essential condition of growing such crops as green peas for this purpose is that the producing areas must be situated reasonably close to the processing factory. There has has been a steady increase in the total production of green vegetables for canning in Great Britain. In 1930 home production amounted to about one-third of total supplies and 44 per cent of total value. Between 1930 and 1935 the quantity of home produced vegetables used for canning increased almost four-fold and their value nearly three-fold. The most recent information on canning and processing in this country relates to the activities of the industry in 1935. In that year supplies of home canned vegetables amounted to 1,205,000 cwt. as compared with 1,057,000 cwt. imported. In 1937, 1,309,000 cwt. of canned vegetables were imported, or twice the weight imported in the previous year.

Imports of Fresh Vegetables.

It is unfortunate that we have no information of the quantity of fresh vegetables produced in this country. But an indication of the relative importance of home produced and imported supplies may be obtained from statements relating to the value of supplies. The production of fresh vegetables in England and Wales during 1936-7 was valued at £15.4 millions. In comparison, the value of imports of onions, carrots, cauliflower and broccoli, salads and other vegetables amounted to £2,564,000 or to 16.6 per cent of the total value of vegetables grown at home Detailed information on quantities of fresh vegetables imported into the United Kindgom is available, and this shows that in 1934 we imported 11,747,000 cwt. of fresh vegetables including potatoes and tomatoes. In 1936 the quantity was 15,638,000 and in 1937 it was 1,292,000 cwt. The bulk of these imports were onions, potatoes and tomatoes, and in 1937 these represented nearly 93 per cent of the total.

Separate information relating to the quantity of cabbage imported is not available, but in 1937 the total supplies of cabbage and brussels sprouts entering this country amounted to 50,524 cwt. of which 86 per cent came from the Netherlands. The information for green peas and beans is more complete and is available for a number of years. In 1934 we imported 14,428 cwt. of green beans and 15,113 cwt. of green peas. Overseas supplies of beans in the subsequent three years were 33,662, 31,996 and 72,189 cwt. Supplies of green peas from other countries amounted to 14,265 cwt. in 1935, to 8,370 cwt. in 1936 and to 20,226 cwt. in 1937. One reason for the enormous increase in imports of beans as compared with green peas is that seasonal prices of the former have generally been above the level for 1927-9, while in every year seasonal prices of peas have been below that level. The decline in imported supplies of green peas in 1936 was not due to any important change in seasonal prices but to the imposition of sanctions against Italy which is normally one of the important exporting countries. Supplies from France and Spain, two other important exporting countries, were however, smaller than in the previous year. No statement relating to monthly imports of these vegetables is available but the season of marketing approximately coincides with that for the home product.

Overseas supplies of cauliflowers and broccoli vary greatly from year to year, and the available information for the years 1934 to 1937 inclusive shows that they were heaviest in 1936. In the first two years imported supplies amounted to 154,000 and 145,000 cwt. respectively ; they increased to 343,000 cwt. in 1936, and in 1937 were down to 169,000 cwt. France is the most important exporter of these vegetables to this country and in 1937 supplies from this source formed 75 per cent of total imports. Next in importance are supplies from the Netherlands followed by those from Belgium. In 1936 supplies from the latter country amounted to more than 18 per cent of the total imports, but in the following year they were negligible. Supplies from the Channel Islands amounted to less than 5 per cent of the total imports in 1937. Supplies from abroad are heaviest during the spring months and particularly during February and March. Total imports during the three months August to October are very small, but there is a continuous increase from November until February or March. Early spring supplies are almost wholly of French origin although the bulk of the annual supplies from the Channel Islands enter this country in the spring. French growers start to export in October or November and the season finishes in April or May. The whole of the supplies from Belgium arrive between April and July, the bulk reaching this country during June. Supplies from the Netherlands are very light during the first three months of the year ; increased supplies arrive during April and May, and in June they represent from 55 to 65 per cent of the yearly total. In subsequent months the volume of exports declines but some increase always occurs during December.

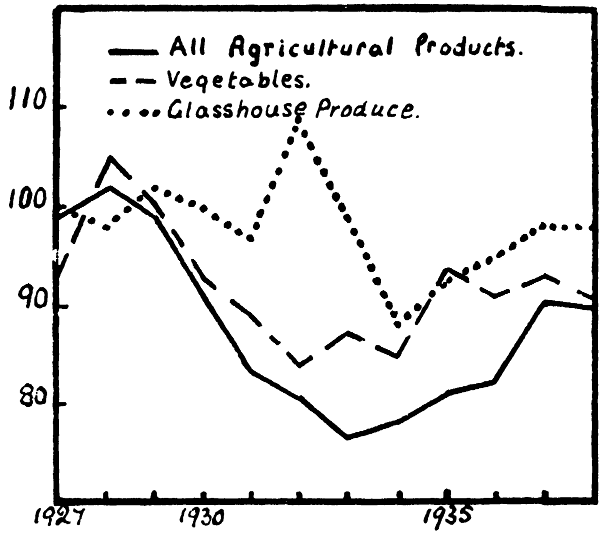
Prices of Vegetables.

One reason for suggesting that farmers in Wales should pay greater attention to market garden crops is the fact that the general level of prices of these crops did not fall as sharply during the years 1927 to 1933 as those of other important agricultural products. In 1933 the general level of agricultural prices was 23 per cent below the average for 1927-9 ; prices of lambs and sheep were 31 and 36 per cent, of fat cattle 24 per cent, and of pigs about 30 per cent below the 1927-9 level. Of the prices for vegetables that for onions shows the greatest fall in being 26 per cent below 1927-9 level in 1933.

Chart I shows that in 1938 the general level of vegetable prices was nine per cent lower than the average for the three years 1927-9,

CHART I.

Prices of Agricultural Products, Vegetables and Glasshouse Products. 1927-9=100



while the general level of agricultural prices was 12.5 per cent lower, or if we take account of government payments for wheat, milk and cattle ten per cent below the level for 1927-9. At no period during the last ten years has the price of any major agricultural product except potatoes been above the 1927-9 level but there are several instances where the prices of market garden and horticultural products have been above that level. If we include potatoes with the market gardening crops the general level of prices of these products has been much more favourable than those for any of the major products.

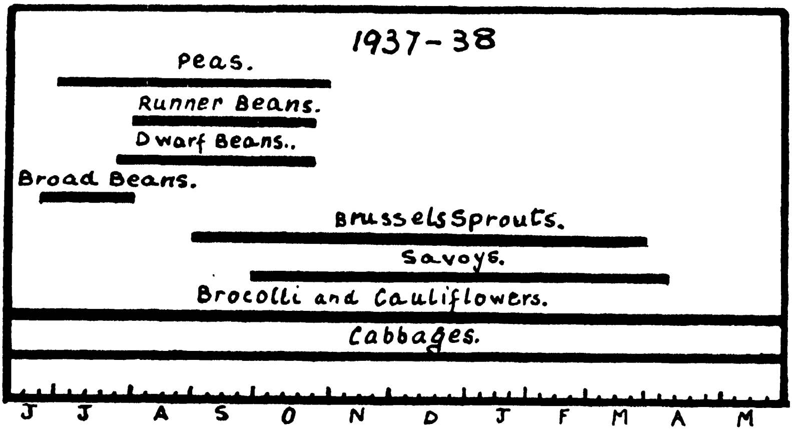
One factor which affects the seasonal prices of individual vegetables is the length of the marketing seasons. In the case of beans and peas the seasons are usually short and customers who look for a change of green vegetable are attracted to supplies of these vegetables. The marketing of brussels sprouts and savoy cabbages extends over a period of from six to eight months. Savoy cabbages however, are not much of a change from ordinary cabbages and prices are usually at about the same level throughout the year. Brussels sprouts have characteristics of their own and are probably more popular with consumers than cabbages.

The cauliflower and broccoli crops taken together provide a continouus supply throughout the year but there occurs some scarcity of the home product during June and again towards the end of the year. Supplies of broccoli begin to get scarce after the middle of May and those of early summer cauliflowers are not very important until towards the end of June. In the late autumn supplies of cauliflowers begin to thin out and the only supplies of broccoli available are those from Cornwall.

There is a continuous supply of different varieties of cabbages available throughout the year but they are usually heaviest in the early spring and early autumn months. Chart No. 2 shows the relationship between the marketing seasons of some of the more important vegetables. There is a relative scarcity of variety of green vegetables during the three months April, May and June, and there is only a limited selection available during the months October to April. The choice is widest during the months July to October when peas, beans and the *Brassicas* are available.

CHART 2.

Length of Marketing Season of Some Vegetables.



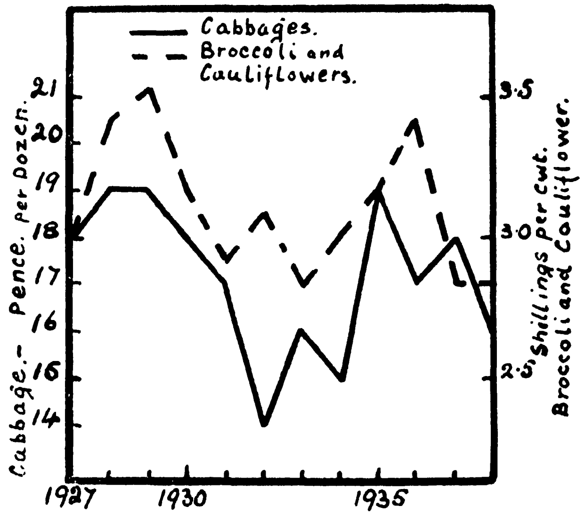
The seasonal and intra-seasonal price changes of the different kinds of green vegetables are considerable. Early supplies of most of the green vegetables command very high prices and as supplies increase prices fall to a minimum but improve again as the end of season's supplies become less. Intra-seasonal changes in prices of broad beans do not show an upward trend towards the end of marketing seasons largely because supplies of peas are then plentiful and the broad bean is not universally popular. Prices of cabbages do not undergo the same intra-seasonal changes largely because supplies are available throughout the year and there is not, therefore, any special attraction. The working classes are the most important consumers of cabbage and they are not attracted to other vegetables until heavy mid-season supplies have forced the prices down to the minimum.

Prices of Cabbage.

During the three years 1927 to 1929 the mean of the monthly prices of cabbage increased from 1s. 6d. to 1s. 7d. per dozen head. In the next two years there was a decline of two pence and in the following year a further fall of three pence, the market value in 1932 being only 1s. 2d. per dozen heads. Although there has been a good deal of fluctuation in the prices in subsequent years the general tendency has been towards an improvement, and in 1938 the mean price was 1s. 4d. per dozen. The mean price was at its lowest level in 1932 and was 26 per cent below the average for the three years 1927-9, while the mean price for 1938 was 16 per cent below that level.

CHART 3.

Prices of Cabbages, Broccoli and Cauliflowers.



When prices of other green vegetables are low, growers of cabbages have some difficulty in finding markets for their total supplies, and in some years considerable areas are fed to livestock or ploughed under. The greatest difficulties occur when good crops of spring cabbages coincide with equally good yields of broccoli. Unless the bulk of the spring cabbages can be marketed before the middle of May difficulty in finding a market may be experienced. Early spring cabbages secure favourable prices but the prices are subsequently influenced to a very great extent by the general supply of broccoli and imported cauliflowers.

During the eight years 1924 to 1931 prices of first quality cabbages, sold in the Liverpool markets, varied between 1s. 6d. and 1s 9d. and in the next three years they fluctuated between 1s. 3d. and 1s. 6d. per dozen. The highest prices since 1924 were obtained in 1936 when the mean for the year was 2s 4d. per dozen.

Intra-seasonal variations in prices of cabbages differ from year to year. In 1934 prices were high during the first half of the year, the weekly prices varying between 2s. and 2s 6d. per dozen, but during the second half of the year prices fell, the range being from 10d. to 1s. per dozen. During 1935, however prices were highest in the second half of the year but at no time did the weekly price quotations exceed 2s. 6d. per dozen. Exceptionally high prices were realised during June, July, and August of 1936 owing to a shortage of supplies of peas and beans. The pea and bean crops were late reaching maturity and with only small supplies of cauliflowers available consumers were dependent upon cabbages as a second vegetable. In July of that year first quality cabbage sold for 4s. per dozen. Although better crops of peas and beans were obtained in 1937 they were again late in reaching maturity and prices of cabbages were again relatively good. During this last year the weekly price quotations indicated steady market conditions but the prices have rarely reached 2s. per dozen.

Prices of Savoys and Brussels Sprouts.

Supplies of savoys are available from early October until early April. Detailed information relating to annual average prices for the whole country is not available but quotations from the Liverpool markets show that for the period 1924-5 to 1937-8 the seasonal prices of first quality heads varied between 1s. and 3s. per dozen. The comparable prices for savoys and other green cabbages seem to indicate that consumers have no marked preference for either. There have been seasons when, during the late months of the year, prices of savoys have been below those for cabbages but in the new year they are generally higher.

Marketing of brussels sprouts commences early in September which is anything from a month to six weeks before that of savoys. Supplies of brussels sprouts are at their maximum at the end of the year and marketing is completed by early April. The seasonal prices of brussels sprouts and of savoys show a good deal of fluctuation and a season of low prices is usually followed by one of relatively good market conditions. During the fourteen seasons from 1924-5 to 1937-8 prices of first quality brussels sprouts at Liverpool varied between 5s 3d. and 9s 6d. per 40 lb. The mean prices of first and second quality brussels sprouts as recorded at representative markets in England and Wales in the last twelve years varied between 13s 6d. and £1. per cwt. In 1933 when prices were generally low those for brussels sprouts were 23 per cent below and in 1936 they were 14 per cent above the average of the three years 1927-9. In 1938 the mean price was 15s 9d. per cwt.

Prices obtained for early season supplies of brussels sprouts differ considerably from year to year. Early supplies of first quality sprouts sold in September 1936 realised 6s. per 40 lb. as compared with 13s in the previous year. The mean of the weekly prices of first quality supplies sold in Liverpool last September was 8s. 2d. per 40. lb. Prices are at their minimum in November and December. In November 1935, 1936 and 1938 the market prices were from 5s. to 5s 4d. while in November 1937 the mean price was 6s 6d. per 40 lb. If early supplies of broccoli are below average owing to some partial failure of the crops or lateness in coming to maturity an important improvement in the prices of brussels sprouts may occur in the early months of the year. During the first three months of 1936 the prices increased from 9s. per 40 lb. in January to 14s. in February and in the latter months the prices were nearly three times those obtained in December 1935. In the following year intra-seasonal prices did not improve from the mid-season low level until the last supplies were marketed in March 1937. Intra-seasonal movements in the market value of the 1937-8 crop were from 9s. 3d. per 40 lb. for the first supplies to 6s. 6d. in November and in the first three months of 1938 the prices varied between 7s. and 9s. The limited choice of green vegetables in the early months of the year enables producers to sell brussels sprouts at prices higher than the average for the season.

Broccoli and Cauliflowers.

The market prices of broccoli and cauliflowers during the twelve years ending 1938 have varied from 15 per cent below to 5 per cent above the average for the three years 1927-9. There is no steady movement from year to year, the prices in any year being determined by the general supply of green vegetables. Fluctuations in prices may be partly due to climatic conditions affecting yields, and partly to differences in acreages sown or planted. In the case of crops with a relatively short growing season the acreage planted or sown in any one season is largely influenced by the prices obtained by producers in the previous year. It is often the case that following a season of low prices, farmers will restrict the acreage under vegetables and there is some tendency to increase acreages after a season of relatively good prices. The prices of broccoli and cauliflowers per dozen heads in each of the last ten years has varied from 2s. 10d. in 1933 and 1938 to 3s. 6d. in 1936. As a result of the continuity of supplies of these crops the seasonal and intra-seasonal price changes are not so great as those for vegetables which have a shorter marketing season.

During the months November to March broccoli sell at anything from 3s. to 5s. per dozen heads. There is some reduction in prices in April and May but the short supplies available in June and July, together with the shortage of alternative vegetables cause prices to improve during these months. Prices remain fairly steady during the period of marketing of green peas, but the heavy supplies of autumn cauliflowers coinciding with heavy supplies of runner beans cause some fall during September and October.

Price quotations at Liverpool in 1934 were the worst for several years, the Cornish broccoli sold well at prices ranging from 4s. to 5s. per dozen but cauliflowers failed to realise more than 3s. per dozen at any time and in September the price was down to 1s. per dozen heads. During 1936 prices of broccoli at Liverpool were above the average for some recent years and the Cornish broccoli sold at anything from 7s. 6d. to 9s. per dozen. The market conditions during 1938 have been about average. Broccoli sold at prices ranging from 3s. to 4s. 6d. during the early months and from 2s. to 3s. per dozen heads towards the end of the season. Early supplies of summer cauliflowers sold at 4s. 6d. or 5s. per dozen heads, but by October market prices had fallen to 1s. 6d. or 2s. per dozen heads. There was some small improvement during November and December but the general level was below the average for this time of the year.

Prices of Broad Beans.

Supplies of broad beans are of less importance than those of peas and of kidney beans. They are usually ready for marketing about the middle of June, generally about one week in advance of peas. The period of marketing usually lasts about nine weeks. The mean prices for supplies offered at Liverpool in each of the last seven seasons have varied between 2s. and 6s. per 40 lb. In the three years 1932 to 1934 inclusive prices were relatively low, the means for the seasons ranging from 3s. 10d. in 1933 to 2s. 4d. per 40 lb. in the following year. Considerably better prices were obtained in the last four seasons, the means ranging from 4s. to 6s. per 40 lb.

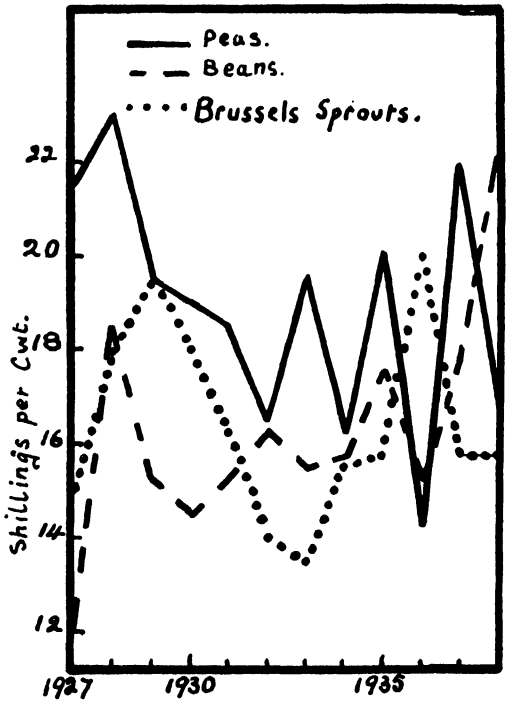
The general tendency is for prices to fall continuously throughout the period of marketing. Early season supplies of first quality beans sold in Liverpool in the last six years have realised from 4s. to 8s. per 40 lb. while those sold at the end of the season realised one-half to one-third of these prices. Early supplies sold in 1936 realised exceptionally high prices, the price quotation for the first supplies at Liverpool being 10s. but by the end of season the price had fallen to 2s. per 40 lb. In contrast early supplies in 1937 sold for 4s. per 40 lb. and apart from a fall in prices in the second week there was a continuous increase throughout the marketing period until the last supplies sold at 8s. per 40 lb. Last year prices at Liverpool fell from 12s. per 40 lb. in the first week to 4s. at the end of the season.

Prices of Peas.

The length of the period of marketing of peas varies considerably from year to year, in 1935 and 1936 it lasted about 13 weeks, while in 1937 it extended over 19 weeks.

CHART 4.

Prices of Peas, Beans and Brussels Sprouts.



The prices quoted at representative markets in England and Wales for first and second quality green peas have in each of the last twelve years, varied between 14s. and 23s. per cwt. Market prices during the four years 1927 to 1930 varied bstween 19s. and 23s. per cwt. and in the next four years between 16s. 3d and 19s. 6d. During the four years 1935 to 1938 the mean prices were 20s., 14s. 3d., 22s. and 17s. 6d. per cwt. respectively. Seasons in which relatively high prices are obtained often alternate with ones in which prices are below average.

Prices of first quality peas sold in Liverpool show the same intra-seasonal fluctuations from year to year and the general level has remained fairly stable during the last fifteen years. In 1935 the bulk of the best quality green peas sold at Liverpool fetched between 3s. 6d. and 6s. 6d. per 40 lb. Comparable prices ruled during the first half of the next season's crop but late supplies realised only 2s. or 2s. 6d. per 40 lb. The general level of prices,was good in 1937, declining from 10s. to 8s. during the first 8 weeks of the marketing season. In the next five weeks the ruling prices were between 4s. 6d. and 6s. but supplies in the last six weeks of the marketing period sold at 8s. or 9s. per pot. In 1938 most of the supplies in Liverpool sold for about 5s. per 40 lb., early supplies realising 7s. or 8s. while the season ended with prices below the average for the year.

Prices of Dwarf and Runner Beans.

The marketing of dwarf beans commences about the middle of July or about three or four weeks after that of peas. In some years the marketing of runner beans may commence about the same time as that for the dwarf variety but usually it starts two or three weeks later. When growers commence to market runner beans, supplies of peas are at a maximum and often the marketing of these beans and of peas finishes about the same time. Under normal growing conditions the runner bean crop will maintain production until late in the year unless it is destroyed by frosts. The crops were particularly good in 1934 and owing to the absence of any sharp frost during the early autumn, supplies of beans were available until the second week in November. In 1935 and 1936 the periods of marketing were remarkably short, due partly to early frosts in the autumn and partly to a failure of the crops in some districts. In the last two seasons the period of marketing extended from the end of July until the end of October.

Dwarf beans usually command the higher prices. In 1934 prices of dwarf beans in the Liverpool markets remained fairly stable throughout the season at about 8s. per 40 lb. but those of runner beans after remaining fairly steady during July and August, fell during September from 6s. to 1s. per 40 lb. In the following seasons the prices of both varieties have shown the same general intra-seasonal changes. The 1937 and 1938 crops sold for prices above the average for the last six years. Last season early supplies of these vegetables realised anything from 20s. to 30s. per 40 lb. and throughout August the prices of first quality beans fluctuated between 12s. 6d. and 20s. per 40 lb. During last September the weekly price quotations at Liverpool ranged between 12s. and 16s. and late supplies in October sold for 6s. per pot.

Conclusions.

Vegetable crops are more speculative than the common arable ones, the market value of any particular vegetable being dependent not only upon the total quantity available, but also upon the total supply of alternative vegetables. Most of the consumers are in receipt of small weekly incomes and while they may appreciate the importance of green vegetables for the maintenance of a high standard of health, nevertheless they do not place them in the group of first essentials. Any deterioration in the general standard of living of this important group of consumers has an effect upon the general demand for green vegetables. But the evidence shows that during the recent depression, when some weakening in the demand occurred, the fall in the prices of this group of human foodstuffs was less important than that of wheat or of livestock. Adjustments of acreages sown or planted to changes in the market conditions was perhaps one of the important reasons for the maintenance of prices.

The relatively small areas under vegetables in Wales indicate some lack of interest on the part of farmers. This is unfortunate for despite the sharp fluctuations in prices of vegetables from year to year the general level during the last eleven years had been better than that of prices of most agricultural products and especially of those products on which Welsh farming is largely dependent. In general prices of vegetables have not fallen as much as those of cereals and changes in the prices of wheat are only comparable when account is taken of the wheat quota payments.

Early season supplies of green vegetables command the best prices and south Pembrokeshire in particular has the natural conditions conducive to early production. Early potatoes are being produced in that county but the area under broccoli, a crop well worth growing in combination with potatoes, is surprisingly small. Parts of Wales are not ideally situated for market gardening, the cost of transporation to the large consuming areas being an important obstacle. But prices for early supplies of most vegetables are sufficiently high to justify the production of early crops in any district of Wales where climatic and soil conditions are suitable.

The reasons usually given for the relative unimportance of market gardening in Wales are the unfavourable topographical and climatic conditions. Soils at relatively high elevations are a very definite limiting factor to any extensive development of vegetable production in Wales, but there are many large lowland areas, especially the fertile valleys, where the conditions are ideal. The high rainfall is a disadvantage in some districts, especially as it often causes late cultivations and seeding in the spring but the experience of many already engaged in the production of green vegetables shows that the rainfall in many districts of Wales has its advantages, especially in the case of *Brassicas* which have to be transplanted. Droughts during the summer often cause low yields of savoys, sprouts and broccoli in producing areas on the eastern side of England. In Wales there is less danger of drought conditions affecting these crops.

Much more important as a limiting factor is the disinterestedness of farmers. Agriculturists in Wales are not, themselves, very partial to some of the green vegetables. This appears to be very obvious from the absence of such crops from farm and cottage gardens. Kitchen gardens, when cultivated, are often confined to the production of potatoes, carrots and cabbage. There are enormous possibilities of increased consumption of green vegetables in Wales, but even the present demands offer opportunities which should be taken by farmers.

The inclusion of some of these crops in the farming systems will by increasing the number of enterprises, add greater stability to farming. The present dependence of many small-holders in Wales upon extensive enterprises such as store cattle and sheep with some minor interest in poultry and pigs is open to serious objections. The essential conditions for the provision of a high standard of living from small-holdings, especially those under 20 acres in extent, is the inclusion, in the system of farming, of a number of intensive enterprises and for this purpose pigs, poultry and market gardening are possibilities. On many small-holdings there already exists family labour not fully employed and if the addition of a vegetable crop was only sufficient to provide full time employment for the family it would be justified. The provision of the necessary capital may offer some difficulty but capital requirements for most of the outdoor green vegetable crops are not very much greater than those for the common arable crops.

With livestock farming short period adjustments cannot be made to meet unstable market conditions, but with vegetable crops relatively quick decisions can be made. Farmers of large holdings may also find that the inclusion of some of these vegetable crops would add to the financial stability of their farms. The knowledge of the cultural operations, methods of marketing, etc. is easily acquired and most of the tasks connected with the cultivation of these crops can be performed by hired men. The large grassland farmer is up against one difficulty in connection with such crops as peas, broad beans and early summer cauliflowers since the time of marketing coincides with that of hay harvesting. But this objection does not apply to the inclusion of spring cabbage and broccoli in the system of farming. There may be difficulties in certain cases, but every farmer should consider the possibilities of producing some of the green vegetables because of the opportunities for providing fuller employment for the family and hired workers and because the inclusion of some cash crops will tend to limit the present disadvantage of a farming system almost wholly dependent upon prices of cattle, milk and sheep.

THE OPERATION OF THE MILK MARKETING SCHEME IN WALES, 1937-8.

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Milk prices in England and Wales have been subject to some regulation since the formation of the Permanent Joint Milk Committee in 1922. This body consisted of representatives of producers, distributors, and manufacturers, while the terms negotiated by them applied to milk consigned to the London area, although similar committees were later formed in certain of the large provincial centres. But this did not imply that the prices and conditions of sale agreed upon by these representative bodies received universal acceptance as many buying interests did not belong to the negotiating parties, while producers were not obliged to enter into the contracts agreed upon. These voluntary contracts, however, did have an appreciable effect on prices and conditions of sale of milk from 1922 to 1933.

During these years, moreover, there was a considerable increase in milk production. It has been estimated that total production in England and Wales, excluding milk fed to calves, increased from 1,117 million gallons in 1924-5 to 1,263 million gallons in 1930-1, which represents an increase of 13 per cent. In the North and South Wales agricultural divisions the increase was in the region of 17 per cent, the estimated production for these two years being 114 and 134 million gallons respectively.

From 1922 onwards, however, it became increasingly difficult to maintain prices of milk. The increase in the quantity sold off farms could not be absorbed by the liquid market, with the result that most of it had to be utilised for manufacturing purposes. During the greater part of the period of collective bargaining from 1922 onwards the prices received by producers for milk sold in this market were determined by the prices of Canadian and New Zealand cheese. The prices of these products suffered severe declines during the acute fall in world prices at the commencement of the present decade. It is not surprising therefore that the yearly average monthly prices of "surplus" milk fell from 9.62 pence per gallon in 1922-3 to 5.00 pence per gallon in 1932-3. This had the effect of undermining the stability of the liquid milk market and by 1933 the position had become so acute that some measure of re-organisation was essential in order to maintain liquid prices. In October of that year the Milk Marketing Scheme for England and Wales was set up under the Agricultural Marketing Acts of 1931 and 1933. Under the present arrangement undercutting is eliminated as all producers have to register with and sell their milk through the Board on the terms prescribed at the commencement of each contract year.

Five years have now elapsed since the institution of the Scheme, and while this account is primarily concerned with its operation in Wales during the contract year 1937-8* it may, perhaps, be useful to note some of the changes which have occurred in prices and conditions of marketing since the commencement of the Scheme.

Dairy Population, Wholesale Contracts, and Producer-Retailers' Levies.

Numbers of dairy cows in England and Wales increased by 1.2 per cent between 1934 and 1938, the figure for the latter year being 2,609,000. In South Wales the trend has been somewhat similar to that for the national dairy herd, there being an increase of 1.5 per cent from 174,200 in 1934 to 176,800 in 1938. In North Wales, however, numbers of dairy cows declined during this period from 121,700 to 120,000. In fact the size of the dairy herd in this region has shown a continuous fall since 1936. Between 1937 and 1938, however, numbers in England and Wales declined by 5 per cent while in North and South Wales there were slight reductions of 0.16 and 0.84 per cent respectively. In the latter year 46 per cent of the dairy cows in North Wales were in the counties of Denbigh and Montgomery, and in South Wales 54 per cent were in Carmarthen and Pembroke.

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*For reviews of the operation of the Scheme in Wales during 1934-7 see *This Journal*, Vols. XII, XIII and XIV.

Details of numbers of wholesale contracts and producer-retailers' licences in operation in 1934 and 1938 are set out in Table I. The West Midland is included as Monmouthshire has been placed in that region. Numbers of wholesale contracts in England and Wales increased by 30 per cent during the period, while in the two Welsh regions there were over twice as many contracts in operation in the latter year. In the West Midland region the increase amounted to 26 per cent. It will be observed from the Table that the proportion of total contracts in the two Welsh regions have increased during these four years, while that accounted for by the West Midland has shown a slight reduction. In the latter year numbers of wholesale contracts in operation in South Wales approached those in the West Midland.

TABLE I.

Numbers and Proportions of Wholesale Contracts and Producer-Retailers' Licences.

	Wholesale Contracts.				*Producer-Retailers' Licences.*			
	March, 1934.		*September 1938.*		*March 1934.*		*September 1938.*	
	Number.	*Proportion of total.*	*Number*	*Proportion of total.*	*Number*	*Proportion of total*	*Number*	*Proportion of total.*
		%		%		%		%
North Wales......	1,619	2.1	3,268	3.2	2,264	4.7	3,209	5.1
South Wales	4,170	5.3	8,388	8.2	2,555	5.3	3,742	5.9
West Midland	7,054	9.0	8,897	8.7	3,701	7.6	5,147	8.1
All Regions	78,181	100.0	101,708	100.0	48,413	100.0	63,305	100.0

Numbers of producer-retailers' licences in England and Wales increased by 31 per cent during this period. Those for the Welsh regions however were somewhat greater, the proportionate increases for North and South Wales being 42 and 46 per cent respectively. In the West Midland it amounted to 39 per cent. The proportion of total producer-retailers' licences in each of these three regions have therefore shown some increase since 1934. But numbers of licences in these regions in 1936 were higher than in 1938, although proportions were lower. In England and Wales numbers of licences decreased by 2,481 between March 1936 and September 1938.

Changes in Sales on Wholesale Contract.

These changes in the size of the dairy herd and in numbers of wholesale contracts provide some indication of the trends in sales of milk during the last five years. In England and Wales total contract sales have increased from 716,437,000 gallons in 1933-4 to 905,537,000 gallons in 1937-8, which represents an increase of 26 per cent. The two Welsh regions however have shown increases very much above the average. In North Wales the increase amounts to about 60 per cent, the actual gallonages sold on wholesale contract in these two years being 13,862,000 and 22,161,000 respectively. In South Wales the increase was as much as 69 per cent, total contract sales having advanced from 24,605,000 gallons in 1933-4 to 41,562,000 gallons in 1937-8. But the increase in the West Midland region only amounted to 23 per cent which was somewhat below the average for all regions, the actual gallonages being 63,909,000 in 1933-4 and 78,295,000 in 1937-8.

It is, however, important to enquire how much of these increased sales went into the liquid market and how much were utilised for manufacturing purposes. In Table II the percentage increases and decreases in sales to these two markets during the past five years and for the last two contract years are given.

TABLE II.

Increases and Decreases in Sales.

	1937-8 over 1933-4.			*1937-8 over 1936-7.*		
	Liquid Sales.	*Manufacturing Sales.*	*Total Contract Sales.*	*Liquid Sales.*	*Manufacturing Sales.*	*Total Contract Sales.*
	%	%	%	%	%	%
North Wales	+24.2	+134.3	+59.8	+20.4	+10.8	+15.6
South Wales	+70.7	+65.3	+68.8	+18.4	—1.9	+11.1
West Midland	+24.6	+19.8	+22.5	+11.4	—7.5	+ 2.5
All Regions	+18.0	+49.0	+26.4	+7.0	—0.7	+ 4.4

Since the commencement of the Scheme liquid sales in England and Wales increased by 18 per cent and manufacturing sales by 49 per cent. Liquid sales, however, constitute about two-thirds of total contract sales while the excess of the quantities sold liquid and for manufacturing in 1937-8 over the quantities thus sold in 1933-4 both amounted to 95,500,000 million gallons. In North Wales manufacturing sales have shown much the greater increase and of the 8¼ million gallons increase in total contract sales in 1937-8 over those in 1933-4 about 27 per cent went into the liquid and about 73 per cent into the manufacturing market. In South Wales on the other hand liquid sales increased by 71 per cent and manufacturing sales by 65 per cent, and in 1937-8 sales on wholesale contract were 17 million gallons greater than in 1933-4. Of this quantity 11¾ million gallons or 69 per cent represented liquid sales and 5¼ million gallons or 31 per cent represented manufacturing sales. In the West Midland region liquid sales have shown relatively greater increases than have sales of manufacturing and 61 per cent of the increase in total contract sales in 1937-8 over 1933-4 went to the liquid market and 39 per cent represented manufacturing sales.

In 1937-8 total contract sales in England and Wales increased by 4 per cent over the previous year. Whereas each of the eleven regions showed some increases those for the two Welsh regions were considerably above the average for the whole country, while that for the West Midland was below the general average. There were also increases in liquid sales in every region during the last contract year, but here again those for North and South Wales were very much above the average. Sales of manufacturing milk were slightly lower in England and Wales during 1937-8 and every region participated in this decline except the North Western, Far Western, North Wales, Mid Western and the Southern.

The two Welsh regions are among those which have shown relatively great increases in sales. But the sales per cow are still comparatively low. Between 1934-5 and 1937-8, however, the total sales per cow in North Wales increased from 180 to 214 gallons, while the figure for South Wales was about 260 gallons during both years.* But the average for England and Wales stands at about 400 gallons. It is probable that yields in Wales are lower, but even so it is still true that there are considerable reserves of milk in the rearing districts which may come forward to the market if prices in alternative markets should become very depressed.

Nominal Contract Prices (Liquid) and Actual Realised Prices.

Since the inception of the Scheme the nominal contract prices for liquid milk have shown a steady increase. During the first contract year the prices per dozen monthly gallons were fixed at 13s. 9d. for ten regions and 14s. 4d. for the South Eastern. But in the succeeding contracts no such distinction was made.

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*Measured on all available cows.

The nominal contract prices for 1937-8 were originally fixed at 15s. 11d. But owing to the severe drought and late frosts in the spring of 1938 costs of production increased considerably. The Board accordingly asked for an advance in the contract prices in the summer months, but this was contested by the Central Milk Distributive Committee and received unfavourable comment from the Milk Consumers' Committee for England and Wales. The producers' case was therefore placed before the " Consulted Person," who awarded an increase of 4 pence per gallon in July, thus raising the prices per twelve monthly gallons from 15s. 11d. to 16s. 3d. It may be stated moreover that these were the prices for ordinary milk. During this same contract year producers of Tuberculin Tested milk were brought within the Scheme and Tuberculin Tested milk sold as such fetched an additional 2 pence per gallon.

But the actual realised prices for liquid milk are not likely to be equal to these nominal prices owing to the variations in the quantities sold at the different monthly prices. The actual position is set out in Table III.

TABLE III.

Nominal and Realised Prices for Liquid Milk.
(Pence per gallon.)

	Nominal Prices.	*Realised Prices.*			
Year.	*All Regions.*	*All Regions.*	*North Wales.*	*South Wales.*	*West Midland.*
1933-4	14.01	13.96	13.75	13.75	13.78
1934-5	15.09	15.08	14.94	15.08	15.12
1935-6	15.25	15.23	15.26	15.18	15.29
1936-7	15.25	15.21	15.19	15.03	15.20
1937-8	16.25	16.24	16.26	16.15	16.25

The actual realised prices for England and Wales and for the three regions recorded in Table III have increased each year, but owing to the greater seasonality of sales, the values for North and South Wales were generally below the average for the whole country. The increases during the last contract year were particularly marked and amounted to 1.03 pence over all regions. In the Welsh and West Midland Regions the increases were somewhat greater.

Manufacturing Sales and Prices.

It will be seen from Table IV that the proportions used for manufacture in England and Wales and for the Welsh and West Midland Regions showed some reductions in 1937-8 over the previous year, while it has previously been noted that except in North Wales gallonages also declined during the latter year. This was probably due in some measure to the efforts of the Board, who have acquired powers to divert milk from the manufacturing to the liquid market should the need arise while under the allocation plan they are empowered to transfer manufacturing milk from the lower to the higher-priced categories. These powers were extensively used, especially during the winter months.

TABLE IV.

Proportions used for Manufacture.

	1933-4.	*1936-7.*	*1937-8.*
	%	%	%
North Wales	32.4	49.5	47.4
South Wales	32.6	36.1	31.9
West Midland	43.8	47.5	42.9
All Regions	26.9	33.4	31.7

In order to expedite the task of raising realisation values for manufactured milk, the Board laid down " standard quantities " for milk used for lower category products on which rebates may be claimed. During the six months October to March of the 1937-8 contract, the standard quantities consisted of the sum of 75 per cent of the gallonage used for hard cheese, 50 per cent of the gallonage used for butter, and 75 per cent of the gallonage used for condensed milk for export during the corresponding half of the 1935-6 contract. No rebates were allowed to manufacturers who used for low category products during these months quantities in excess of the standard quantities, except with the written consent of the Board. During the entire 1937-8 contract year the gallonage of milk manufactured into butter in England and Wales declined by 23.6 per cent over the previous year; that manufactured into cheese declined by 9.6 per cent, while the gallonages utilised for condensed milk, milk powder, and fresh cream increased by 28.2, 60.0 and 9.1 per cent respectively.

This feature is also brought out in Table V. It will be observed that considerable increases occurred in the proportionate amounts utilised for the most remunerative categories during 1937-8 at the expense of the least remunerative. Owing to the new arrangements it is not possible to give the proportionate utilisation on a regional basis.

TABLE V.

Utilisation of Milk for Manufacturing Purposes 1936-7 and 1937-8.

Products.	*1936-7.*		*1937-8.*	
	Percentage of total.	*Average Utilisation Value per gallon.*	*Percentage of total.*	*Average Utilisation Value per gallon.*
	%	*d.*	%	*d.*
Butter	34.9	4.29	26.9	5.31
Cheese	20.1	5.59	18.3	6.45
Condensed Milk	21.6	6.73	28.0	7.51
Milk Powder	2.9	6.07	4.7	7.00
Tinned & Bottled Cream, etc.	5.6	6.40	5.8	7.37
Fresh Cream	14.9	7.51	16.3	8.51
Total or Weighted Average	100.0	5.75*	100.0	6.88*

*Excluding Subsidy. Including Subsidy 5.80 (1936-7) 6.91 (1937-8).

The average utilisation values per gallon for each product were appreciably higher during the last contract period. The quantity of milk available for cheese making during the winter months was considerably depleted owing to the operation of the allocation plan and the Board succeeded in raising the price of milk for manufacture into certain kinds of cheeses by 1d. per gallon for the months January to September, 1938, with the exception of May and June.

The average utilisation value for all manufactured milk, excluding subsidy, increased from 5.75 pence per gallon in 1936-7 to 6.88 pence in 1937-8. But the Government grant under the Milk (Amendment) Act of 1937 only raised the realisation value for the latter year to 6.91 pence. This, however, represents an increase of 0.11 pence over the previous year, and 0.45 pence over the total realisation value for 1933-4.

Deductions from Contract Prices and Producer-Retailers' Levies.

Deductions from contract prices (i.e. differences between liquid and pool prices) increased considerably during the early years of the Scheme. This implied that producer-retailers' levies also increased as the size of the deductions was the most important factor in the determination of the contributions of this class of producer. But as the pool deductions and therefore the levies increased there was much unrest among producer-retailers who claimed that they were paying too high a contribution towards the maintenance of the pool prices of their respective regions. Consequently the Board reviewed the whole position and incorporated a new system of contributions in the amendments to the Scheme which became operative on October 1st, 1937.

These new arrangements were therefore in force throughout the whole of the 1937-8 contract. The rates have been standardised according to grade of milk and apply to the whole scheme area. Producers of Tuberculin Tested milk contribute 1¼d. per gallon, accredited producers 1½d. and ordinary producers 2¼d. But a reduction of ½d. per gallon is made in each case for level-delivery and a further discount of a ¼d. per gallon is allowed if payment is made within fourteen days of the relevant accounting day.

The position of producer-retailers has been alleviated somewhat as a result of the new scale of payments. During 1937-8 the net average contribution over the whole country was 1.33 pence per gallon as against 1.43 pence for the previous year. But the average for the last contract year was still 0.44 pence per gallon above that for 1933-4. It is not possible however to give the rates of net levies for the regions with which we are particularly concerned as the gallonages on which allowances for quality milks were earned and discounts for prompt payments made are not known.

Pool Prices.

We are now in a position to consider the pool prices for 1937-8. It has already been noted that over the whole country liquid sales realised about one penny per gallon more and manufacturing milk about 1.11 pence per gallon more than in the previous year. The weighted average pool price was the highest since the inception of the Scheme and worked out at 12.92 pence per gallon which was 0.93 pence higher than that for the previous year. Every region received a higher pool price in 1937-8 than in the previous year, the increases ranging from 0.81 pence per gallon in the Northern to 1.03 pence in the East Midland. It will be seen from Table VI that the weighted averages for the West Midland and the two Welsh regions were slightly lower than that for the whole country owing to higher proportions used for manufacturing and to greater seasonality of liquid sales.

TABLE VI.

Weighted Average Pool Prices.
(Pence per gallon.)

	1933-4.	*1936-7.*	*1937-8.*
North Wales	11.33	11.57	12.59
South Wales	11.70	11.79	12.71
West Midland	11.34	11.64	12.58
All Regions	11.83	11.99	12.92

For England and Wales as a whole the total payments to producers on the basis of pool prices amounted to £48,728,704 in 1937-8. The corresponding amounts for North and South Wales were £1,162,198 and £2,200,683 respectively, while that for the West Midland region amounted to £4,104,103. These represented considerable increases over the corresponding values for the previous year.

The Inter-Regional Compensation Levy during 1937-8 varied from 1d. to 2½d. per gallon. The proceeds are paid into a central fund and are then re-allocated between the different regions to eliminate any undue disparity between the regional pool prices. Details as to the re-allocation between regions are not available for 1937-8 but in previous years producers in the West Midland and the two Welsh regions have in common with those in certain of the other remote regions benefited considerably, while producers in the near-in regions where high proportions are sold to the liquid market have made net-contributions to the fund. There is now much more uniformity in the regional pool prices than was the case in the early years of the Scheme and since February 1935 the monthly regional variations have not exceeded one penny per gallon.

Retail Prices.

It has already been noted that liquid sales on wholesale contract in England and Wales in 1937-8 increased by 7 per cent over the previous year. Sales by producer-retailers are estimated to have increased by about 30 per cent from 103,312,000 gallons in 1936-7 to 134,000,000 in the following year. The official estimate of fresh milk consumption in 1936-7 was 0.42 pints per head per day so that the figure for the last contract year would be somewhat higher.

It is rather unfortunate however that retail prices have continued to increase. It is true of course that the minimum prices prescribed by the Board for the different localities remained unchanged between 1934-7, yet the actual retail prices charged to consumers increased. While distributors in a number of localities requested a lowering of these minima, distributors in others charged prices higher than those prescribed by the Board. It will be seen from Table VII that the minimum prices for the contract year 1938-9 have been increased by 8 pence per dozen monthly gallons in rural districts and small towns, and by 4 pence per dozen gallons in the remaining divisions as compared with the corresponding prices for the previous year. Distributors in the more populous localities are presumably allowed a wider margin owing to higher distribution costs.

TABLE VII.

Minimum Retail Prices.

	Per Twelve Monthly Gallons.		
	1934-7.	*1937-8.*	*1938-9.*
	s. d.	*s. d.*	*s. d.*
(1) All Rural Districts, and Urban Districts, and Municipal Boroughs of less than 10,000 inhabitants.	23 4	24 4	25. 0
(2) Urban Districts, Borough and County Boroughs with a population exceeding 10,000 but under 25,000	25 0	26 0	26 4
(3) Urban Districts, Borough and County Boroughs outside the South-Eastern Region with a population exceeding 25,000	26 0	27 0	27 4
(4) Urban Districts, Boroughs, and County Boroughs within the South-Eastern Region with a population exceeding 25,000 including the City of London and the Metropolitan Police District	26 8	27 8	28 0

In Table VIII the actual retail prices and the retail price indices for large and small towns are set out.

TABLE VIII.

Actual Retail Prices : England and Wales.*

Year.	*Average Price per quart*** *(pence).*	*Index Numbers.*		
		Large Towns.	*Small Towns.*	*Total.*
1932-3.	5.8	163.6	167.7	165.6
1933-4	6.0	169.3	177.5	173.4
1936-7	6.4	178.9	186.3	182.4
1937-8	6.8	188.6	196.9	192.8

*Ministry of Labour Gazette.
**July 1914=3½d=100.

It will be observed that a continuous increase has occurred. In 1937-8 the actual average price was 13 per cent above that for 1933-4 and 17 per cent higher than that for 1932-3. Taking the latter year as a base the retail prices for small towns have shown the relatively greater increase, the percentage increases for large and small towns for this period being 15.2 and 17.4 per cent respectively. Consumers in some rural districts have been adversely affected as it was possible to buy milk much more cheaply in those areas in the pre-Scheme days.

Quality Milks.

Numbers of producers of milk of quality standard are given in Table IX.

TABLE IX.

Numbers and Proportions of Producers of Quality Milk (September 1938).

	All Regions.		*North Wales.*		*South Wales.*		*West Midland.*	
	No.	%	*No.*	%	*No.*	%	*No.*	%
Accredited	22,711	100	973	4.3	1,336	5.9	1,552	6.8
Tuberculin Tested	2,841	100	151	5.3	475	16.7	238	8.4
Attested	1,947	100	58	3.0	1,088	55.9	89	4.6
Accredited and Attested.	411	100	5	1.2	390	80.6	1	0.2
Tuberculin Tested and Attested	1,045	100	45	4.3	272	26.0	85	8.1

During 1937-8 numbers of Accredited Producers in England and Wales increased by 7.5 per cent over the previous year and the accredited gallonage by 11.9 per cent. In the two Welsh regions the increases were somewhat above and in the West Midland rather below the general averages. In October 1938 the quality premium to such producers was increased from 1d. to 1¼d. per gallon.

Producers of Tuberculin Tested milk were within the Scheme throughout the whole of the 1937-8 contract year and received a premium of 2½d per gallon. It will be seen from Table IX that South

Wales contains a very high proportion of such producers. But it is even more remarkable that over 50 per cent of the producers with Attested Herds should be within the South Wales region, while the greater part of them are found in the two counties of Carmarthen and Pembroke. The premium obtained by these producers amounts to 2 pence per gallon. The Accredited and Attested and the Tubercilin and Attested producers are of course included under the three main groups and both earn premiums of 3½d. per gallon. Financial assistance is obtained from the State for the payment of premiums on all of these quality grades.

Conclusions.

The Scheme has now been in operation for a sufficient period to enable a brief resumé of its general effects to be made. What may be termed as its immediate aims have been achieved, namely, the prevention of any further fall in producers' returns and the strengthening of the bargaining power of producers by negotiating as a body on terms and conditions of sale of milk. Consequently the wider problems arising from the relation between the different parties interested in its production, manufacture, and distribution are assuming greater importance. Thus on the one side we have the producers who wish to be suitably remunerated for their product, and on the other the different buying interests and the general consuming public who wish to secure adequate supplies at reasonable prices consistent with the cleanliness and quality of the milk.

Total sales have increased appreciably since the inception of the Scheme but the greater part of the increase has been utilised for manufacturing purposes and the liquid market has had to bear an undue share of the burden thus imposed. In fact the expansion of the low price market has entailed a much heavier burden than was at first anticipated. Liquid prices have therefore had to be increased in order to effect the slight increase which has occurred in producers' returns, although realisation values for manufacturing have also shown some improvement.

Distributors' margins advanced from 10.82 pence per gallon in 1933-4 to 11.22 pence in 1937-8. In the latter year the net farm price was 11.44 pence per gallon. The allowance for distribution was therefore approximately equal to the price received by the farmer. The high level of distribution costs has been commented on from time to time by many official and unofficial bodies. It has been stated that there is much lack of co-ordination in both the wholesale and retail fields, and that margins are fixed in relation to the costs of the less economical units. These have the effect of raising the prices charged to consumers. It appears that the rationalisation of methods of distribution is regarded as an urgent need in some quarters, while important proposals regarding distribution were contained in the *Milk Industry Bill* which was recently withdrawn.

Retail prices have increased continuously since the institution of the Scheme, and this feature has no doubt militated against expansion in consumption. It is true that some increase in consumption has occurred, but this is slight in relation to the efforts made to advertise and to popularise milk drinks. The Milk in Schools Scheme and the schemes for assisted sales to special classes of consumers are steps in the right direction. And while these are desirable features it is nevertheless true to say that any appreciable increase in consumption will only be achieved by stimulating consumption among the general body of consumers. Lack of appreciation of milk is a rather important inhibition, but the high price of milk is undoubtedly a much more important limiting factor. While representatives of producers may nominally fix prices, they must always make a judicious use of this power as in the long run they must have regard to the reactions of consumers to the prices they may fix. And it is probable that the prices which consumers may be prepared to pay in normal circumstances will be less than those which they would tolerate when it was generally recognised that the industry was in dire straits.

SOME ASPECTS OF THE SHEEP INDUSTRY IN WALES.

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The agricultural income derived from the sheep industry of England and Wales amounted to about £19 millions in 1936-7, or 12.6 per cent of the total income from livestock and livestock products and 8.5 per cent of the total agricultural income. The position in Wales is one showing relatively greater reliance than this on sheep and sheep products in the total of agricultural income and the markets for sheep are therefore very important. Stated broadly the factors affecting supplies and prices are :—Production and supplies in this country ; imports and prospects of production in countries supplying imports ; general commercial and industrial conditions and prospects, and monetary factors. It is beyond the scope of this article to discuss all the problems arising as a result of the consideration of these factors in the general situation. So the present discussion is confined to a consideration of some problems which appear to be of immediate importance in obtaining a true perspective as regards the sheep and lamb trade in Wales at the present time. Any study which helps to obtain this perspective is useful for it is evident that in the field of agricultural policy the sheep problem is one of the most important now facing farmers in Wales, and action or inaction on their part in relation to the trade in sheep and their products will exert considerable influence on the material welfare of agriculturists in the Principality.

Sheep Population.

Numbers of sheep in Great Britain have been increasing in recent years and are now around pre-war levels, while those in Wales are the highest on record.

Table I shows that the cycle of change in the sheep population of the Principality has been of irregular duration. The periods between successive low numbers of sheep have varied from a minimum of 2 years to a maximum of 9 years, while the periods between successive high numbers have varied between 2 and 11 years.

Numbers of sheep have shown a strong upward trend from the latter half of the last century to the present time. There have been occasions, however, when this tendency was interrupted for rather long periods, especially in the late seventies and early and late

TABLE I.

Numbers of Sheep in Wales.
(Years of high and low numbers.)

Year.	*Interval between high and low numbers. (Years.)*	*Interval between successive low numbers. (Years.)*	*Interval between successive high numbers. (Years.)*	*Total Sheep. (000').*
1867	—	—	—	2,410
1869	2	—	—	2,923
1871	2	4	—	2,885
1874	3	—	5	3,278
1877	3	6	—	3,051
1878	1	—	4	3,122
1881	3	4	—	2,584
1885	4	—	7	2,953
1886	1	5	—	*2,694
1887	1	—	2	2,922
1888	1	2	—	2,917
1891	3	—	4	3,460
1895	4	7	—	3,203
1896	1	—	5	3,420
1897	1	2	—	3,401
1903	6	—	7	3,749
1904	1	7	—	3,728
1909	5	—	6	4,054
1913	4	9	—	3,600
1916	3	—	7	4,117
1920	4	7	—	3,331
1927	7	—	11	4,231
1929	2	9	—	3,945
1932	3	—	5	4,362
1934	2	5	—	4,174
1938	4	—	6	4,565

eighties of the last century. Some recovery occurred in 1891 and though this was not maintained there was no substantial decline during that decade. From 1896 onwards each high level in the series of numbers was higher than the one preceding it. But some of the low levels also became progressively lower during the present century until in 1920 the sheep population was the lowest recorded for 25 years. That position, however, was largely due to the effects of the War. In the present decade numbers have never been below 4 millions and they are now over 4½ millions (1938).

This strong tendency for the sheep population to increase absolutely in the Principality has been accompanied by some interesting changes in numbers of sheep in relation to human population, total land area, cultivated land area, arable land area and in numbers of cattle. The position is illustrated in Table II.

It will be seen from Table II that there were more sheep per 1,000 of the human population in Wales in 1871 than in any sub-

TABLE II.

Numbers of Sheep in Wales.*
(excluding Monmouth.)

	Per 1,000 of				
Year.	*Population*	*Acres in total area.*	*Acres in total cultivated area.*	*Acres in total arable land.*	*Per 100 Cattle.*
1871	2,253	570	1,039	2,437	454
1881	1,809	519	886	2,544	376
1891	2,130	681	1,121	3,694	426
1901	1,994	722	1,214	3,888	461
1911	1,769	756	1,296	4,958	485
1921	1,458	677	1,236	4,151	444
1931	1,890	858	1,607	6.777	532
1937	2,027**	883	1,681	7,726	535

*Extracted from Table in " Livestock of the Farm" (Edited by C. Bryner Jones). Vol. IV. page 4.
**Subject to revision.

sequent year. The lowest level was reached in 1921, when the figure was under 1,500. Since then, however, a strong recovery has occurred and in 1937 it is estimated that there were over 2,000 sheep per 1,000 of population, and the number in 1938 must have been above this level. Thus the sheep population is now approaching the position it occupied in relation to human population during the census years 1871 and 1891.

Numbers of sheep in relation to land area is an important consideration in the economy of sheep farming and the figures given in Table II show that sheep have become more numerous in relation to total land area, cultivated area, and arable area. These increases in numbers of sheep in relation to land area and more especially in relation to land in the cultivated and arable states may raise serious problems in the management of flocks in the near future.

Numbers of sheep relative to those of cattle show practically the same trends as those already shown to exist between human population and land area, there being a tendency for sheep to gain in relative numerical importance. In all the years shown, with the exception of 1881, there have been more than four times as many sheep on farms in Wales as there have been cattle and in the present decade more than five times as many.

These facts prove that numbers of sheep are increasing both absolutely and relatively in the general economy of farming in the

Principality. The degree of reliance placed on sheep farming, though increasing in the various counties of Wales, shows considerable variation from county to county. Total numbers of sheep in each county in Wales in 1937, in descending order of size of flocks, with the percentage increases which have occurred in numbers in each county since 1893, are set out in Table III.

TABLE III.

Sheep Population (1937) and changes since 1893.

	Numbers.	*Per cent to total.*	*Per cent. of 1893**
Montgomery	576,075	12.9	149
Brecon	536,726	12.0	119
Denbigh	503,836	11.3	162
Merioneth	425,978	9.5	105
Radnor	351,219	7.9	129
Glamorgan	346,133	7.8	118
Carmarthen	330,897	7.4	136
Caernarvon	326,153	7.3	136
Cardigan	308,706	6.9	130
Monmouth	267,783	6.0	126
Anglesey	173,177	3.9	283
Pembroke	161,869	3.6	127
Flint	154,795	3.5	217
Total	4,463,347	100.0	135

*The year 1893 is taken as a base year because it provides a convenient point from which to get to pre-war by ten year intervals.

The increases in total sheep population in the different counties have been somewhat varied. Those showing the greatest relative increases are Anglesey and Flint, which are counties with comparatively low numbers of sheep. Increases in numbers of ewes kept for breeding have occurred in all counties except Cardigan, Merioneth and Pembroke, while numbers in the classes " sheep under a year old " have increased and those over a year old (excluding those in breeding flocks) have declined in all the counties.

Nature of Sheep Stocks.

Declines in numbers of sheep over a year old and increases in numbers of sheep below a year both absolutely and in relation to total ewes in flocks in Wales are some of the most important changes which have been and are still going on in the character of sheep husbandry. These changes began in the last century and have proceeded with added pace in the present one. (Table IV.)

TABLE IV.

Ratio of Other Sheep to Breeding Ewes.

Year.	*Breeding Ewes.*	*Other Sheep 1 year and over.*	*Other Sheep under 1 year.*
1893	100	81	90
1903	100	58	92
1913	100	53	85
1923	100	39	90
1933	100	24	85
1937	100	12	100

These figures show that a lowering in the age of slaughter has been going on steadily for a considerable time in Wales and now three-year-old wethers are rarely found in flocks and only few two-year-old wethers. Reductions in numbers of these classes of sheep in flocks has made possible an increase in breeding flocks without causing any increase in the intensity of sheep farming in relation to available land.

Another important effect is that sheep stocks in the Principality as a whole are now managed in a way designed to meet the change in the public taste for lamb in place of mutton. This follows closely the change which has occurred in the nature of imports of mutton and lamb which now comprise about 23 per cent mutton and about 77 per cent lamb. Since most flockmasters in Wales have been following the same practice it will be readily appreciated why sheep over a year old (other than those in breeding flocks) constituted less than 6 per cent of the sheep stocks of Wales in 1937. (If figures on a comparable basis were available, it is probable that they would show this class of sheep to be still less important in flocks in 1938.)

The character of sheep flocks in the different counties of Wales, however, shows considerable variation, and the movement towards a lower age of slaughter is much more striking in some than it is in others. The actual position for 1937 is given in Table V, the counties being set out in order of declining number of sheep over a year old (other than those in breeding flocks).

In the year 1893 the counties of Merioneth, Radnor, Brecon and Caernarvon had more sheep over a year old outside breeding flocks than were in them. Ten years later not one county in Wales showed this position and since that time all counties have shown continuous declines in the ratio of other sheep over a year old in flocks, until in 1937 the position shown in Table V was attained. It is quite clear that at present the main areas in which wethers

TABLE V.

Relation of Sheep Flocks to Land Elevation (1937).

	Number of Sheep per 100 Breeding Ewes.		*Ratio of land surface.*		
	Other Sheep over 1 year old.	*Sheep under 1 year old.*	*Up to 500′*	*500′-1,000′*	*Over 1,000′*
Radnor	33	121	3.0	42.0	55.0
Brecon	27	107	6.0	37.0	57.0
Merioneth	20	98	19.0	34.0	47.0
Caernarvon	11	96	48.0	23.0	29.0
Cardigan	10	95	32.0	44.0	24.0
Montgomery......	10	106	21.0	43.0	36.0
Monmouth	8	99	61.0	23.0	16.0
Glamorgan	7	90	59.0	27.0	14.0
Denbigh	5	91	30.0	35.0	35.0
Carmarthen	4	101	52.0	38.0	10.0
Flint	4	100	68.0	28.0	4.0
Pembroke	3	105	82.0	16.0	2.0
Anglesey	2	90	99.9	0.1	—

are found and wether mutton produced are Radnorshire, Breconshire and Merionethshire, and to a much lesser extent Caernarvonshire, Cardiganshire and Montgomeryshire. Some yearling sheep may be transferred by flockmasters from one county to another after the census returns of June 4th have been compiled and these may be sold in fat condition before the next livestock census. Even allowing for this inter-county transference of sheep over a year old, it is unlikely to alter the position stated here as regards the geographical distribution by counties of the production of wether mutton in Wales.

Sheep farmers in all the counties of Wales now produce and sell mainly lambs in fat or store condition and even those farming in counties showing relatively high ratios of sheep over a year old outside breeding flocks are in a position to do this because there are large numbers of sheep within their county boundaries. It might be said therefore that the sheep enterprises of Wales to-day are mainly designed to cater for the fat lamb trade—either by direct feeding on rearing farms or by transfer of store lambs from upland rearing farms to lowland feeding farms—and also for the maintenance of breeding flocks for these purposes.

There is a further change occurring in the nature of sheep farming which is somewhat difficult to demonstrate statistically. This is the tendency for concentrating on the production of early lamb. A good deal of experimental work has been done in selecting the best crosses for early lamb production and the knowledge thus gained is being extensively applied by flockmasters.

TABLE VI.

Sheep Population of Wales and Monmouth*
(In thousands).

Year.	*Ewes for Breeding.*	*1 year and over.*	*Under 1 year.*	*Total.*
June, 1935	2,004	435	1,839	4,278
December, 1935	2,065	238	834	3,137
Difference	+61	—197	—1,005	—1,141
June, 1936	2,057	428	1,863	4,348
December, 1936	2,119	211	880	3,210
Difference	+62	—217	—983	—1,138
June, 1937	2,070	320	2,073	4,463
December, 1937	2,190	195	963	3,348
Difference	+120	—125	—1,110	—1,115
June, 1938	2,406	294	1,865	4,565
December, 1938	2,326	248	871	3,445
Difference	—80	—46	—994	1,120

*The figures for 1938 are not strictly comparable with the previous years because of change in the basis of enumeration.

An estimate of this position may be made from the data given in Table VI. If the numbers of ewes for breeding in the December returns are regarded as the potential lamb yield of the following season—working on the assumption of one lamb per ewe—the lamb yield for 1936 would be about 2,065,000 lambs. In the following June there were 1,863,000 sheep under a year old on farms in Wales. Since all of these must have been born after June 4, 1935, their numbers would represent lambs left over on that date from the total yield. Thus the difference between this figure and the estimated total number of lambs born amounts to 202,000. Between June 4 and December of the same year, 983,000 lambs disappeared from flocks. The same process of estimation gives the following figures of disappearances in 1937 and 1938.

	Thousands.
Lambing season to June 4th, 1937	46
June 4th to December 4th, 1937	1,110
Lambing season to June 4th, 1938	325
June 4th to December 4th, 1938......................	994

According to these estimates, between the lambing season and December the total of lambs which disappeared from flocks in each of the years were about :—

	Thousands.
1936	1,185
1937	1,156
1938	1,319

These figures appear quite reasonable and the only remarkable thing about them is the wide variation between the three years in the marketing or deaths of early lambs before June and the apparent steadiness of these figures from that time to the last month of the year. It is probable that the wide variations noted in the estimated disappearances of lambs are traceable to two main causes. The first, but not necessarily the most important, is related to the nature of seasons as affecting the lamb crop and rapidity of maturing; the second is related probably to market conditions and these may lead to haste or caution in marketing in accordance with flockmasters' estimates of the market outlook.

Since it is clear from these estimates that the results of one year cannot be taken as a measure of producers' interest in the early lamb market it seems essential to assume that the average position over the three years would provide a better measure of interest in this somewhat specialised market. If it can be assumed that death rates before and after June are constant there is no need to estimate them in order to arrive at the proportion of lambs marketed before and after the beginning of June for in that case the ratios would remain unaltered. On this basis, it might be said that in recent years an average of 15 per cent of lambs were marketed before June and 85 per cent between that date and December. The evidence from estimates given here indicates that there is a tendency to produce sheep meat at young ages in response to expressions of consumers' preferences. And during the last three years it is estimated that the market supplies of sheep meat produced inside Wales and sold inside and outside the borders of the Principality were made up in the following way :—

	%
Lambs sold before June 4th	10
, ,, June 4th to December 4th	56
,, ,, between December 4th and following census	10
Fat wethers	4
Fat ewes and Rams	20
	100

This estimate shows that the nature of the sheep meat produced in Wales as regards the distribution between mutton and lamb is practically the same as that imported from overseas. It would appear therefore that the flockmasters of the Principality have gone as far as their overseas competitors in supplying the article demanded by consumers especially in so far as this is achieved by reduction in age of slaughter of sheep.

Lowering the average age of slaughter in itself, however, is not enough to achieve the purpose of providing the article demanded by consumers, for such matters as finish, size, and uniformity enter into market standards. Recent information of grading results of sheep sent to Birmingham* from some areas in Wales under the grade and dead weight scheme of the Ministry of Agriculture is informative in this connection. The scheme under which these sheep were sent is encouraged by the Welsh Agricultural Organisation Society, Ltd., Aberystwyth. Sheep were sent mainly from North Cardiganshire and some from Breconshire. The records analysed are comparable for the seasons 1937-8 and 1938-9 and the results are shown in Table VII.

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*One lot sent to Liverpool.

TABLE VII.

Sale of Lambs by Grade and Dead Weight.

Month.	*Number of Lots.*	*Number in Grades.*				*Average dead weight per lamb in grades (lb.).*			
		1	*2*	*3*	*Re-jects.*	*1*	*2*	*3*	*Re-jects.*
Season 1937-8.									
June	9	75	63	19	4	31	30	27	24
July	12	158	135	11	5	33	30	28	24
August	11	63	85	17	1	34	31	29	25
September	10	52	67	11	—	36	32	28	—
October	22	163	307	33	5	33	29	25	26
November	23	177	325	11	—	32	29	24	—
December	15	102	241	39	1	31	26	24	24
January	3	7	57	8	4	31	28	25	25
February	2	19	53	28	8	33	29	26	26
March.	1	8	36	24	7	33	28	25	24
Season 1938-9*									
June	16	155	126	4	1	32	30	32	22
July	19	138	185	32	8	36	32	27	28
August	7	94	107	19	2	35	32	27	25
September	7	16	186	40	9	34	31	26	33
October	26	225	392	56	1	34	29	24	28
November	26	266	519	62	4	30	27	26	20
December	8	81	192	41	6	30	26	21	17
January	7	64	101	37	61	34	29	23	21

*Few lambs were sent to this centre for slaughter after January, 1939, under the W.A.O.S. scheme.

The numbers of sheep included in this sample are small and they are recorded here in order to illustrate the trend as regards quality and weight of sheep sent from these areas in Wales for slaughter in Birmingham. Practically all the local agents handling these lambs, and through the agency of whom they are dispatched to the slaughtering and grading centre, state that they rarely get the best lambs for selling in this way. Producers, so local agents state, tend to sell the best lambs at home or at local livestock markets. Thus it may well be that the sample given here reflects less credit on the fat lambs produced in Wales than is their proper due.

The records for 1937-8 show that the average weight of lambs in the 1st grade during the season was 33 lb., and the average during the months varied from 31 lb. to 36 lb. dressed carcase weight. On the average, weights were much lower in the 2nd grade and over the year averaged 29 lb. Average weights of carcases in separate consignments in both these grades showed remarkable uniformity. Numbers of lambs in grade 3 and " rejects " were very low, and weights usually lower than those in grades 1 and 2.

The experience in 1938-9 as regards weight was very similar to that of the previous season. Average weights in grade 1 during the months of 1938 varied from 30 lb. to 36 lb., while those in grade 2 were lower, ranging from 26 lb. to 32 lb. Again there were only a small proportion of lambs in grade 3 and in general average weights of dressed carcases were lower. Numbers of " rejects " generally were low except in 1939.

Most of the lambs in both 1937 and 1938 were placed in grades 1 and 2, but many more were in the latter grade than in the former except in the month of June. But all lambs that attained grades 1 and 2 were well finished and provided good carcases. This sample shows therefore that flockmasters in the areas from which these lambs were drawn were aware of market requirements and were capable of meeting them in a reasonably satisfactory way. And the remarkable consistency in the grading and weight returns for each month shows that consignments in the two years were very similar. In both years they did well under the exacting inspection and grading to which they are subjected under the Ministry's scheme. In one respect, however, they did badly in 1938-9 for 1st grade lambs on the average only made the same prices as " rejects " in the previous season.

It must be realised that the evidence given only refers to supplies from June onwards, but so far as it goes it demonstrates that flockmasters in the Principality are aware of the nature of public demand, and are endeavouring to satisfy it by producing sheep meat in conformity with current market standards and requirements. Records covering the period before June are not available, but there is no reason for believing that producers of lambs are failing to do before June what they are able to do during and after that month. Thus it might be said that sheep farmers in Wales are giving serious attention to the problems involved in providing consumers with the goods required. But they are still making too little use of the method of selling by grade and dead weight.

When market requirements as regards quality of product are closely met producers are accustomed to expect that adequate rewards in markets follow as a natural result. This comfortable view was completely falsified during the year 1938 when producers in Wales had raised and fattened more sheep for sale than ever before. The reasons for this somewhat disappointing and unsatisfactory position are to be found mainly in supply and demand relationships and in the failure of raisers of home produced mutton and lamb to understand these and organise sheep markets sufficiently to extract from them much better prices than those realised in 1938.

Supplies and Prices.

Conditions in the sheep trade in England and Wales in 1937 led flockmasters to expect continuance of prosperity in the industry. They acted on the basis of this estimate and increased their breeding flocks. Excellent yields of lambs were obtained in 1938 and consequently supplies on representative markets showed remarkable increases by comparison with some previous years as is shown in Table VIII.

TABLE VIII.

Supplies of Fat Sheep.

(England and Wales).

(Representative Markets) (Weekly Average).

(In hundreds).

Month.	*1935*	*1936*	*1937*	*1938*
January	406	377	383	383
February	355	379	343	372
March	371	383	324	361
April	410	445	381	372
May	500	484	404	455
June	450	497	433	495
July	461	471	438	493
August	477	448	456	501
September	457	452	457	479
October	433	452	399	487
November	388	387	374	446
December	362	345	282	358
Total	5,070	5,120	4,674	5,202

The figures in Table VIII show that supplies on markets were much heavier in 1938 than they were in 1937 and the degree of excess increased as the year progressed. From June onwards supplies were heavier each month (except December) than in the corresponding months of the previous three years. This pressure of supplies on markets had the inevitable effect of reduction in prices as is shown by the prices obtained for fat sheep and fat lambs at representative markets.

The remarkable fall in fat sheep and fat lamb prices in 1938, by comparison with those obtainable in the same months in the previous years, is very significant. Average prices of 1st and 2nd quality descriptions of fat lambs were never less than 1d. per lb. below those of the previous year and in many months they were more than 3½d. a lb. (deadweight) below them. Average prices of similar descriptions of fat sheep showed even greater declines than those for fat lambs by comparison with prices obtainable in the same periods in 1937.* This experience in markets came as a complete shock to producers, especially when they realised that overseas descriptions of mutton and lamb were about maintaining their price position in the wholesale markets (See Table IX).

TABLE IX.

Prices of Fat Lambs. (England and Wales).

Representative Markets.

(Pence per lb. deadweight).

Average of first and second quality.

Month.	*1935*	*1936*	*1937*	*1938*
January	—	—	—	—
February	—	—	—	—
March	16.8	16.4	18.4	15.9
April	15.9	15.8	17.6	15.1
May	13.8	13.6	16.1	12.5
June	11.4	12.0	14.1	10.8
July	10.9	11.5	13.3	9.6
August	10.4	11.4	12.8	9.4
September	10.4	11.6	12.1	9.2
October	10.4	11.4	11.4	9.4
November	10.5	11.0	11.4	9.2
December	—	11.3	11.0	9.8

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*A small proportion of the decline in producers' prices has been attributed to falls in prices of offals, sheep skins and wool. But these have rarely exceeded 1d. per lb. on dressed carcase weights.

TABLE X.

Prices of Fat Sheep. (England and Wales).
Representative Markets.
Crossbreds (Pence per lb. deadweight).
Average of first and second quality.

Month.	*1935*	*1936*	*1937*	*1938*
January	11.4	10.5	11.3	10.9
February	11.6	10.3	11.8	10.5
March	12.4	10.3	13.0	10.1
April	12.4	10.8	13.4	10.1
May	11.1	10.3	13.1	8.9
June	9.8	10.0	12.0	8.0
July	9.4	9.8	11.4	7.6
August	9.0	10.0	11.1	7.3
September	9.0	10.3	10.6	7.4
October	9.3	10.3	10.3	7.5
November	9.5	10.4	10.4	7.9
December	10.3	10.9	10.8	8.9

Prices of Mutton and Lamb in Wholesale Markets.

In recent years prices of home produced descriptions of mutton and lamb in wholesale markets have moved in the same direction as those of fat sheep and lambs in representative markets. Movements in prices of imported kinds of these meats on wholesale markets were very similar in pattern to those of home produced sorts except in 1938. In that year the trend in prices of home and imported kinds of mutton and lamb were different and this is an important factor in the present trade situation relating to sheep meat.

In 1938 considerable changes occurred in the relative price positions of these meats. The average monthly price of 1st quality English mutton was never more than 75 per cent above that of the same quality New Zealand or 94 per cent more than that of Argentine mutton. But the price premium of the English product declined to 44 per cent of New Zealand mutton in some months and to 59 per cent of that of Argentine mutton of similar quality. The average position in 1938 by comparison with 1937 was that the price premium on first quality English mutton had declined from 86 to 56 per cent in the case of the same quality New Zealand mutton and from 110 to 72 per cent in the case of Argentine mutton. These losses of premiums in prices of home produced mutton were all the more remarkable while the prices of the imported kinds remained steady or showed only fractional price declines during 1938.

The net position for the last few years is shown in Table XI.

TABLE XI.

Wholesale Prices of First Quality Mutton.
(Pence per lb.)

Year.	*English.*	*New Zealand.*	*Argentine.*	*Ratio of English to*	
				New Zealand.	*Argentine.*
1934	9½	5⅝	5⅛	169	185
1935	9⅝	5¼	4⅝	183	208
1936	9¼	5⅜	4⅞	172	189
1937	10¼	5½	4⅞	186	210
1938	8⅜	5⅜	4⅞	156	172

Practically the same features as those shown for mutton are found in the wholesale market for lamb in the years 1937 and 1938. In the period 1934-7 the wholesale prices of British lamb of 1st quality were 48 to 55 per cent greater than those of New Zealand lamb and 61 to 72 per cent above those of Australian lamb of similar quality. Prices of 1st quality early British lamb were over twice those of New Zealand lamb of the same quality in April and May, 1937. A year later the same quality British lamb was exactly twice the price of the New Zealand product in April and had declined in May to one and a half times the price of New Zealand lamb. The price premium of the British description compared with New Zealand was 20 per cent at its lowest point in 1937, while it showed only 1 per cent premium at certain periods in 1938. From September to December, 1938, the price premium on the British sort was 1 to 4 per cent and this represented one-eighth to three-eighths of a penny per lb. dressed carcase weight. The average position between prices of New Zealand and British lamb in 1937 and 1938 shows that the price premium on British lamb declined from 55 per cent in the former year to 31 per cent in the latter. Prices of Australian lamb of 1st quality in 1937 and 1938 show the same trend as that existing between British and New Zealand lamb. But Australian lamb is always lower in price than the New Zealand product and the price relationships are thus different in degree. In the three months March, April and May of 1937, British lamb was 2¼ to 2½ times the price of 1st quality Australian lamb. In 1938, only in April was the British product twice the price of Australian. The lowest price premium in any month in 1937 was 24 per cent, but in 1938 it was as low as 12 per cent. The average position during the years 1937 and 1938 was that the price premium on British lamb of 1st quality declined from 69 to 45 per cent on Australian 1st quality.

The position for the last five years is summarised in Table XII.

TABLE XII.

Wholesale Prices of First Quality Lamb.
(Pence per lb.)

Year.	*British.*	*New Zealand.*	*Australian*	*Ratio of British to*	
				New Zealand.	*Australian*
1934	11¾	7⅝	6⅞	154	171
1935	11⅝	7⅝	6¾	152	172
1936	11½	7¾	7⅛	148	161
1937	12¼	7⅞	7¼	155	169
1938	10½	8	7¼	131	145

The change in the relative wholesale prices of British 1st and New Zealand and Australian lamb of 1st quality is clearly due to maintenance or strengthening of prices of imported lamb and weakness in prices of home-produced lamb. This weakness developed to such an extent in 1938 that New Zealand lamb was selling in wholesale markets at prices very near those of home-produced lamb. There was only ⅛d. per lb. difference in November and in the same month the average price of 1st quality Australian lamb was within ⅞d. of that of British lamb. This price position was maintained even when the imports of these meats increased. The imports of mutton and lamb into the United Kingdom were 340,859 tons in 1937 and 345,702 tons in 1938. Of course imported mutton and lamb can be and is put in cold store before finding its way finally to markets. Still the fact remains that one of the main lessons taught by the experience of imported mutton and lamb in markets last year was that increased supplies caused considerable weakening in prices of home produce and did not do this in the case of imported supplies. These differences in price experiences in markets are attributed mainly to the following characteristics of imported supplies. They meet current market requirements, are well standardised, strongly supported by marketing organisations and effective advertising campaigns.

Retail Prices.

Prices by retail are a concern of producers only in so far as they affect consumers' demands and are reflected in producers' prices. And when declines or increases occur in the latter, it is customary to regard them as arising from real relationships between actual supplies and consumers' demands. With the fall in producers' and wholesalers' prices in 1938 it would have been expected that retail prices would have followed the same trend.

Evidence in relation to retail prices of home-produced and imported mutton is available in official publications and this throws considerable doubt on the assumption that retail prices decline with, and by as much as, those in representative primary markets and those by wholesale.

Average retail prices of British legs of mutton were higher at the commencement of the first four months of 1938 than they were in the corresponding period of 1937; subsequently declines in retail prices occurred and at their lowest points these were 1¼d. per lb. below those of the same months in the previous year. But retail margins between prices by wholesale 1st quality English mutton and British legs of mutton by retail were higher in each month of 1938 than they were in 1937. The increase in margins rose from ¾d. per lb. in January to a maximum of 2¾d. per lb. in May, and then declined steadily to ¾d. in October and remained at about that level to the end of the year. Thus it is perfectly clear that the magnitude of the declines in wholesale prices and in producers' prices for mutton cannot be attributed to differences in consumers' reactions in markets in 1938 as compared with 1937 except to a very slight degree, for average, retail prices were only ¼d. per lb. lower in 1938 while retailers' margins were distinctly greater (See Table XIII).

TABLE XIII.

Wholesale-Retail Margins English Mutton.

(Pence per lb).

	*British Legs Retail**		*English 1st. Wholesale.***		*Margin.*	
Month.	*1937*	*1938*	*1937*	*1938*	*1937*	*1938*
January	15¼	16¼	9	9¼	6¼	7
February	15¼	16¼	9⅜	9¼	5⅞	7
March	15¼	16¼	10⅞	9¼	4⅜	7
April	15¾	16	11⅝	9½	4⅛	6½
May	16¼	16	11¾	8¾	4½	7¼
June	16½	15¾	11⅜	8⅝	5⅛	7⅛
July	16½	15¾	10½	8	6	7¾
August	16½	15½	10¼	7⅝	6¼	7⅞
September	16½	15½	9⅞	7⅜	6⅝	8⅛
October	16½	15¼	9½	7½	7	7¾
November	16¼	15¼	9¼	7⅜	7	7⅞
December	16¼	15¼	9⅜	7½	6⅞	7¾
Year.	16	15¾	10¼	8⅜	5¾	7⅜

*Retail Prices—Ministry of Labour Gazette.

**Wholesale Prices—Imperial Economic Committee Report and Agric. Market Report Average of weekly prices.

Increases in retail price margins also occurred in the market for imported kinds of mutton, but these arose mainly as a result of increases in retail prices as is shown in Table XIV.

TABLE XIV.

Wholesale-Retail Margins Frozen Mutton.
(Pence per lb.)

	*Frozen Legs Retail.**		*New Zealand 1st**. Wholesale.*		*Margin.*		*Argentine 1st.** Wholesale.*		*Margin.*	
Month.	*1937*	*1938*	*1937*	*1938*	*1937*	*1938*	*1937*	*1938*	*1937*	*1938*
January	9¾	10½	5⅜	5⅞	4⅜	4⅝	4⅞	5	4⅞	5½
February	9¾	10½	5½	5⅝	4¼	4⅞	4⅞	4⅞	4⅞	5⅝
March	9¾	10½	5⅜	5½	4⅜	5	4⅞	5	4⅞	5½
April	9¾	10½	5⅜	5½	4⅜	5	5⅛	4⅞	4⅝	5⅝
May	10	10½	5¼	5½	4¾	5	5	4⅞	5	5⅝
June	10	10¼	5¼	5½	4¾	4¾	4¾	5⅛	5¼	5⅛
July	10	10¼	5¼	5½	4¾	4¾	4⅞	4⅞	5⅛	5⅜
August	10	10¼	5½	5¼	4½	5	4⅞	4¾	5⅛	5½
September	10¼	10¼	5⅝	5⅛	4⅝	5⅛	5	4⅝	5¼	5⅝
October	10¼	10½	5¾	5⅛	4½	5⅜	5⅛	4⅜	5⅛	6⅛
November	10½	10½	5⅝	5	4⅞	5½	4⅞	4½	5⅝	6
December	10½	10¼	5¾	4⅞	4¾	5⅜	5	4½	5½	5¾
Year.	10	10⅜	5½	5⅜	4½	5	4⅞	4⅞	5⅛	5½

*Retail Prices—Ministry of Labour Gazette.
**Wholesale Prices—Imperial Economic Committee Report and Agric. Market Report Average of weekly prices.

Retail price margins, measured by the method adopted in this article, show that those on home-produced and imported sorts of mutton were approaching the same level in 1937. But in 1938 margins of the former sort increased very considerably by comparison with those of the latter.

The relationship between retail and wholesale prices of lamb cannot be worked out in the same way as that for mutton because retail prices of lamb are not obtainable in any official publication in Britain. The general impression is that the decreases in retail prices of lamb were greater in 1938 than those for mutton. These decreases, however, appear to have been small by comparison with the actual declines in prices which occurred in producers' and wholesalers' markets. If the case presented here is moderately accurate there cannot be any reasonable doubt concerning the increases which occurred in retail price margins in the year 1938 as compared with 1937. And it is unlikely that consumers showed much of a change in the nature of their requirements in mutton and lamb between the two years. So it would be somewhat difficult to account for increased retail margins in 1938 by attributing them to changes in consumers' behaviour in markets leading to relatively increased demand for good joints and relatively poor demand for the inferior cuts and joints. Changes in public taste which are so profound as these take a much longer time than a year to become firmly established and the decline in purchasing power of certain sections of the community in 1938 as compared with 1937 would tend to force consumers to buy the cheaper rather than the dearer joints. But it is possible, of course, that consumers expressing preferences for good joints of mutton and lamb over a long period may have forced retail butchers to sell this meat at a level little different from that prevailing in 1938 when prices in producers' and wholesalers' markets were strong. And in so far as they were unable to sell the cheaper parts at profitable levels some actual losses may have been incurred by them. Then the price level of the best cuts and joints must have risen in price in order to carry the loss incurred in the sale of the poorer parts. This form of averaging between prices of good and poor parts is done in butchers' businesses, as also is averaging between prices of the various kinds of meats found in butchers' shops. Official support of such trade practices have been expressed quite recently.* But whatever may be said of the accuracy of and justification for the arguments advanced by retail butchers to account for the discrepancies between the prices which producers get and those which consumers pay, it is certain that producers of mutton and lamb must take all the means available to them to prevent a recurrence of the price experience which they had in markets in 1938.

Conclusions.

This study shows that the sheep industry in Wales has undergone very far reaching changes during the present century and that these changes are still proceeding. Numbers of sheep in relation to human population have tended to decline up to 1921, but since that time they have tended to increase. It is estimated that the relation between numbers of sheep and human population in Wales in 1938 was approaching that prevailing in the '90's of last century. Sheep in relation to land area, cultivated area and arable area, have shown almost continuous increases in numbers and they have tended to become continuously more important in relation to numbers of cattle. This leaves no doubt therefore that the export surplus of sheep in Wales to-day is at a higher level than at any time since the war.

Numbers of sheep in the class " other sheep over a year old " have shown absolute and relative decline and the nature of sheep exported and slaughtered now consist mainly of sheep under a year old. When these changes were occurring in the early years of the present century there was little increase in the intensity of sheep farming as a consequence. For the removal of sheep over a year old (other than sheep for breeding) from flocks made it possible to draft breeding ewes into them without increasing numbers of total sheep carried in relation to land area. But actual sales would increase because of partial liquidation of the class of sheep over a year old outside breeding flocks and because more lambs were available for sale from the larger breeding flocks. But little, if any, additional area of land was called for to meet this type of increase in the intensity of sheep farming, but more systematic control of grassland and root crops was necessary. Later, however, real increase in the intensity of sheep farming occurred because the absolute increases in the breeding flocks were greater than the declines in other sheep over a year old. This process of increase in sheep flocks has now gone so far that some sheep farmers are doubtful of the wisdom of further rapid increases until such factors as diseases of sheep, and diseases of crops resulting from heavy stocking with sheep, can be better controlled.

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*Food Council: Meat Prices. 20th February, 1939.

Increasing the intensity of sheep farming in the sense that more sheep are kept on farms and more sold in the meat market at lower weights and ages than formerly raises very serious issues for flockmasters. For, if they are to produce the small carcase weight now demanded, many of them insist that flocks must be increased in order to sell as much weight of meat as they sold previously, and this they consider essential if the sheep industry is to contribute as much as before to the total agricultural income. The willingness of producers to meet current market requirements in uniformity of product and in size of cuts and joints of mutton and lamb largely depends on their ability to increase the size of flocks, and this in turn will depend mainly on their capacity to discover effective methods of management to obtain satisfactory lamb yields and to control diseases in sheep and in crops which sheep require for maintenance and fattening.

The evidence produced in this study shows that knowledge of market requirements is possessed by flockmasters. Lowering in age of slaughter, decrease in carcase weights and greater uniformity of carcases as regards quality have been achieved. The interest which has been shown in the Ministry of Agriculture's scheme for sale of lambs by grade and dead weight and the practical use made of this scheme also shows that producers are becoming more and more aware of the ways in which they can satisfy consumers' preferences. And it is certain that the grading scheme of the Ministry of Agriculture is having a much wider influence than is indicated by the numbers of sheep sold under it. Producers visit centres where the slaughtering, grading and weighing are done, watch these processes and comment on the way they are carried out; while the fact that the " National Mark " can be applied to these carcases when they are sold by wholesalers to retailers or by retailers to consumers is an added source of interest. It is certain that if more parties were organised and conducted over these centres for the purposes of following the course of sheep from the farm to the slaughterhouse, through the several processes occurring there, and then given some insight into the effects of the standardisation of grades on the functions of wholesaling and retailing meat the appreciation of the need for rapid expansion of selling by grade and dead weight would be appreciated more thoroughly and quickly. Practical participation in the scheme would then occur very much more readily.

In these days considerable attention is given to advertising and it is certain that effective country-wide advertising of home-produced mutton and lamb must be preceded by grading and the standardisation of grades. This lesson has been thoroughly taught and admirably learnt by some of the most effective of overseas competitors in the mutton and lamb markets in Britain. The New Zealand Meat Board spends about £30,000 a year in its own currency on advertising meat in this country and this has been done in some of the populous areas of South Wales. All this would not have been possible but for the fact that grading and standardisation had preceded and made possible the conduct of effective advertising campaigns.

But it is also quite certain that grading and standardisation and advertising of themselves would not have relieved the pressure of home-produced supplies of fat sheep and lambs on markets in 1938 to an extent sufficient to secure remunerative prices. In order that this be achieved, these processes would have to be accompanied by adequate marketing organisations which would regulate market supplies in such a way as to relieve the pressure of total supplies on markets. This would be accomplished by a combination of import control and organised marketing of home-produced supplies. And if producers of fat sheep and lambs in Wales, and for that matter Britain as a whole, are to safeguard themselves against a repetition of their disastrous experiences in markets in 1938, they must achieve this by control over supplies or by a system of standard prices supported or unsupported by control over total market supplies. Producers would be better off in the long run by the adoption of a marketing scheme under the Agricultural Marketing Acts of 1931 and 1933. But it is unlikely that this form of marketing organisation will be developed due to the lack of enthusiasm of producers and opposition from other interests. Still the fact that this form of organisation is possible may help producers of sheep to secure more favourable treatment as regards the level of standard prices obtained than they would get if these Acts were not in existence and the knowledge of their successful application to some products of the farm fresh in the minds of producers. But what farmers may now gain by economic-political pressure may be lost in the same way as other political triumphs were lost in times gone by; whereas a sound developing marketing organisation controlled by livestock producers and designed to obtain for them an appropriate share in the British market for mutton and lamb would prove very much more reliable in its results in the long run. It is unlikely, however, that such a scheme would prove so attractive as standard prices in the short run and thus producers will probably be favourable to the latter. But it seems certain that the producers of sheep and of livestock generally are still paying for their lack of foresight in organising a scheme of livestock marketing on the lines of the recommendations of the Re-organisation Commission for Fat Stock.

Effective control of the supply side of the fat sheep and lamb market would enable producers to exercise considerable influence over retailers' margins. These margins, however, are not the direct concern of producers and they are only indirectly concerned with them because prices charged to consumers may decrease or increase the quantities of various types of meats purchased. Producers think that retail margins in relation to mutton and lamb were excessive in 1938 and thus exerted a restrictive effect on consumers' demands for these meats. The Food Council's Report on Meat Prices sums up the whole position in this way:—

> (a) 1937 was probably an unsatisfactory year for butchers in view of the high level of wholesale meat prices generally.
>
> (b) 1938 was a better year for butchers since they increased their margins on imported mutton (slightly) and home killed mutton (greatly), and delayed any substantial reduction in retail prices until the autumn. Though the wholesale price of home killed and imported beef rose slightly, retailers were able to maintain their margins.
>
> (c) The slump in sheep and lamb prices in the first half of 1938 was followed by a similar reduction in wholesale carcase prices and was partly due to excessive offerings of lambs, probably due to a good breeding season and subsequent drought.
>
> (d) Retail butchers appear to have taken advantage of the fall in sheep and lamb prices in the first half of 1938 to recoup themselves for any lack of profits in 1937. They appear however to have maintained an exceptionally high margin of retail over wholesale prices for mutton from October 1937 till the end of 1938. We hope that butchers will reduce this margin substantially at an early date.

(e) We do not consider that the Government should intervene in the retail marketing of meat, unless or until any combinations of distributors make intervention necessary for the protection of consumers or producers.

(f) The following courses appear to us to be worthy of consideration for the benefit not only of the home producers but also of the distributors and consumers :—

  (1) The creation of a better demand for the cheaper cuts of meat. We recognise that valuable work in this direction is already being done.

  (2) A greater uniformity of quality in connection with the various classes of home produced meat, in order to enable the consumer to have a better opportunity than now exists of purchasing in accordance with recognised grades.

  (3) Encouragement of all possible means of meeting the demand for smaller joints.

  (4) The greater recognition by traders of the practical application of the science of refrigeration including the process known as the "conditioning" of meat.

  (5) The better regulation of livestock supplies to the markets, and of both home produced and imported meat to the wholesale meat markets.

MILK COOLING ON THE FARM.

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It has long been realised that low temperatures are of much assistance in the preservation of farm products, notably milk, butter, cheese and meat.

The most important factors in the production of good keeping quality milk are efficient cleansing and sterilisation of dairy utensils together with immediate cooling of the milk to at least 55°F.

It has been shown that the development of the bacterial content of milk is dependent on the temperature at which milk is held and that very little growth takes place during the first 24 hours at temperatures below 50°F. Park (1901), Ayers, Cook and Clemmer (1918) and Hastings (1922) have investigated the effect of the holding temperature on the bacterial flora. Further, Ayers and Clemmer (1918), Finkelstein (1919), Hunter (1919) and Sherman and Wing (1933) have shown that the growth of the coliform group of organisms is retarded by holding at low temperatures.

The following results show the effect of different holding temperatures on milk produced at the College Farm, Nantcellan. A series of ten morning's milk samples were tested when four hours old, divided into three portions and held for 24 hours at 40°F., 60°F. and 70°F. respectively. Colony counts, coliform tests and methylene blue tests were carried out according to the technique prescribed in the Ministry of Health Memorandum. (1937).

TABLE I.

Effect of holding College Farm milk at different temperatures.

Means for 10 samples.

Holding temperatures.	*Colony count per ml.* (*G.M.*)	*Coliform count per ml.* (*G.M.*)	*Methylene blue reduction* (*hrs*).	
			37°-38°C (*A.M.*)	*15°-17°C* (*A.M.*)
Fresh milk (4 hours old)	2.700	0.1	7.0	48
After holding at 40°F. for 24 hours	2,500	0.1	8.1	50
After holding at 60°F for 24 hours	69,000	100	5.0	26
After holding at 70°F for 24 hours	5,000,000	10,000	0.9	<12

The practical significance of the above results is the extreme importance of the holding temperature on the keeping quality of the milk. Methylene blue reduction at 15° — 17°C. has been used as an index of the keeping quality in this case. Provan, Dudley and Thomas (1936) found that the results of this test show a good correlation with keeping quality as determined by taste and clot on boiling. The quality of the milk shows no deterioration when held for 24 hours at 40°F., but there is a marked reduction in keeping quality after holding at average summer temperatures.

The influence of favourable growth temperatures is most evident in the case of the coliform organisms which have increased a thousandfold and a hundred thousandfold at 60°F and 70°F. respectively. The increase of these organisms at the above temperatures was also studied during the examination of a further series of samples from the College Farm. (Table II.) No coliform organisms were detected in 1/100 ml. of the fresh milk but after holding at 60°F. for 24 hours, 81 per cent. of the samples examined gave a positive result at this dilution.

The effect of efficient cooling on the bacterial content and keeping quality of milk has been investigated by Stenhouse Williams, Mattick and Hoy (1924). They found that 98 per cent. of the milks

TABLE II.

Coliform count per ml. (Geometric means).
Morning's milk held at 60° and 70°F.

Samples held at :—	*Fresh milk 4 hours old.*	*8 hours.*	*12 hours.*	*28 hours.*
60°F.	0.1	5	9	490
70°F.	0.1	5	11	7,943

with temperatures between 41° and 50°F. on sampling attained the desired bacteriological standards for designated milk ; 95 per cent. of the samples between 51° and 60°F. and only 60 per cent. of those between 61° and 70°F. attained these standards. Frayer (1930 and 1932) also showed that the damage to the future quality of the milk is roughly proportional to the length of time before it is cooled.

The results of the examination of designated milk samples from Mid and West Wales during the past two years show that over 80 per cent. of the winter and spring samples attain the desired bacteriological standards whereas only 55 per cent. of the summer samples and 62 per cent. of the autumn samples are satisfactory. (Table III). The samples were taken by qualified sampling officers and arrived at the laboratory within 10 hours of milking. They were transported in insulated wooden boxes during winter and spring and in iced containers during summer and early autumn. The temperatures on arrival at the laboratory were between 40° and 55°F. The unsatisfactory nature of the summer and autumn milk is attributed to poor cooling and inefficient sterilisation of dairy utensils.

TABLE III.

Results of the grading of tuberculin tested and accredited milk samples from Mid and West Wales.

1937 — 38.

Season.	*No. of samples examined.*	*Attaining designated standards.*	
		Number.	*Per cent.*
Winter : December–February	2,552	2,249	88
Spring : March–May	2,966	2,422	82
Summer : June–August	2,730	1,499	55
Autumn : September–November	3,010	1,863	62

It is of course fairly easy and cheap to fix a water cooler in the farm dairy but it is often difficult to obtain a satisfactory water supply throughout the year. The critical months appear to be July, August and September, and occasionally October in droughty seasons.

Most of the farm supplies in Mid and West Wales are derived from springs or shallow wells and in a few cases from Urban Authority pipe lines. The temperature of the water is generally far too high during the critical summer months and the supply is often inadequate for the requirements of the dairy. A combination of a shortage of water, high temperature of the supply, and inefficient sterilisation of utensils (including the cooler) will inevitably result in poor quality milk which will fail to attain the bacteriological standards for designated milk. Records taken over a number of years, at twelve farms licensed to produce tuberculin tested milk show that water cooling during warm August afternoons was very inefficient. The mean temperature of the milk leaving the coolers was 66°F., the lowest recorded being 55°F. and the maximum 80°F.

The College Farm water supply suffers from both the above defects during late summer months. There are two sources; one from a spring in one of the fields and the other from a shallow well—15 feet deep. The water gravitates from these sources to cisterns of limited capacity and from these to the dairy. The temperature of the water at the dairy during summer months ranges from 65° to 72°F. whilst the quantity is often inadequate. Under these circumstances it is not surprising to find that afternoon milk during July and August was only cooled to 70°F. The results of the bacteriological examination of monthly samples of milk taken during winter and summer are shown in the following table :—

TABLE IV.

Winter and Summer milk samples from College Farm, Nantcellan (1925–36). Pint bottles kept at 60° - 65°F on arrival at laboratory and examined at 12-18 hours old.

Season.	*Milking*	*No. of Samples.*	*Colony Count. Stand. Agar. (Geometric means)*	*Per cent. Coliform positive samples. (+1/10 ml)*	*Keeping quality at 60°–65°F. (Hours.)*	*Per cent. samples attaining Grade A. standards.*
December to February.	A.M.	42	6,800	31	82	95
	P.M.	33	14,000	27	84	92
June to August.	A.M.	43	7,100	31	77	86
	P.M.	21	31,000	60	59	60

It was therefore considered advisable to install a direct expansion refrigerator provided with a milk cooler together with a cold storage chest. It has a capacity for cooling 25 gallons of milk per hour, is driven by a ½ H.P. motor from a home produced D.C. electric supply and consumes 4 amps at 110 volts. The equipment is listed at £182 10s 0d. made up of the following items :—

Milk cooler fitted with compressor, delivered and installed—	£113	0	0
Pair of steam sterilising covers	6	0	0
Service Cabinet (cold storage)	62	0	0
Extra for D.C. motor	1	10	0
	£182	10	0

The compressor unit was fixed on a stone counter in front of a hopper window in the dairy, but it was found necessary to replace the hopper window with louvre boards in order to effect a more rapid air cooling of the radiator fins. The cooler occupies the position of the former water cooler and is permanently fixed on a stand. The upper section is water cooled and the refrigerant (Freon, dichloro difluoro methane) circulates in the lower section.

For purposes of cleaning and sterilising, a fixed cooler is unsatisfactory, although the provision of metal covers to facilitate steam sterilisation helped to overcome some of the difficulties. A number of experiments were carried out to test the efficiency of different methods of cleansing and sterilising, the effectiveness of

TABLE V.

Sterilisation of the cooler.

Treatment of cooler.	*No. of tests.*	**Colony count per litre of saline rinsings. Milk agar, 3 days at 37°C.*	**Coliform count per litre of saline.*
Before washing.	5	3,950,000,000	52,000
Cold water, hot water, scrubbed with brush. Followed by cold water.	5	46,000,000	4,800
Cold water, hot detergent and then cold water.	5	37,000,000	1,000
Cold water, hot detergent, cold water and steam hosed for 3 minutes on each side	5	400,000	1,300
Cold water, hot detergent and cold water. Steamed in covers for 15 minutes.	10	20,000	Absent in 50 ml. of rinsings.

*Geometric means.

which was determined by means of bacteriological tests of sterile saline rinsings taken from the cooler (Table V). Before the unit could be considered hygienically clean, steam sterilisation for 15 minutes in the covers was required, in addition to the usual washing with cold water and hot detergent solution. A litre of saline was used for each test and though only a proportion of the viable organisms was removed in the rinsings the method may serve to provide a comparative index of the efficiency of the different treatments. The cooler had been left for a few hours after the morning's milk had been cooled, and it is interesting to observe the enormous numbers of bacteria it harboured before the preliminary washing.

From results in Table V it is seen that washing with cold and hot water removed a large number of organisms but that the unit was left in a highly contaminated condition. The use of hot detergent did not make much difference, but steaming with a hose and jet affected a marked improvement, although the cleansing was still unsatisfactory. Steaming with the covers on for 15 minutes gave satisfactory results ; the first gallon of milk run over after this treatment would wash off less than 5 organisms per millilitre. It is significant that coliform organisms were not entirely destroyed by any method except by thorough steaming.

The plant has been designed to operate either the cooler or the cold storage chest one at a time and the refrigerant is easily diverted to either chest or cooler as required. In practice it is usual to allow the refrigerant to circulate through the cooler for some minutes before use.

Evening's milk is stored overnight in the chest, which in the summer is maintained automatically at a temperature of 40°—45°F. During the winter however, other demands on the electric supply make it necessary to curtail the use of the cold store, and consequently the chest is on the refrigerant for 1½ hours only after the milk has been placed in it. The service cabinet has storage for 160 pint bottles in crates. There has been no mechanical trouble with the plant during the 18 months in which it has been used.

According to specifications the capacity of the plant is 25 gallons per hour of milk cooled to a temperature of 45°F. and to secure this a minimum flow of 75 gallons of cold water is required. The flow of water depends upon the bore of the service pipe and the head of water, and at Nantcellan the available head during the winter rainy periods is only 6 ft, which gives a flow of 60 gallons of water through the cooler. In dry periods however, the supply is such that the head may be as low as 3 ft., when only 36 gallons of water circulates. Further, the maximum rate of flow of milk which at first was only 22 gallons per hour, has increased after

18 months use to over 40 gallons per hour as shown in Table VI. Both these facts i.e. shortage of water and increased flow of milk have, naturally reduced the efficiency of the D.E.R. cooler. It is true that the former defect may be remedied by increasing the water supply and improving the head by pumping the water to a high level service tank. On the other hand the flow of milk may be reduced by partly closing the tap, but this should be standardised by fixing a constant flow regulator similar to those in use on cream separators. In the plant under consideration the milk flow depends upon the setting of the milk tap on the milk container and the perforations on the milk distributing trough on the cooler. From the results it appears that these perforations have become enlarged and consequently allow a greater maximum milk flow over the cooler, but this may be reduced to normal by partly closing the milk tap.

The following table gives the temperatures of the milk at normal flow when leaving both the water section and the refrigerant section of the cooler, together with the temperature of the incoming and outgoing water.

TABLE VI.

Temperature records of the milk and water from the D.E.R. cooler at Nantcellan College Farm.

Date.	*Rate of flow of cooling water, galls. per hr.*	*Maximum Rate of flow of milk over cooler galls. per hr.*	*Temp. of cooling water °F.*	*Temp. of water from cooler °F.*	*Temp. of inflow milk °F.*	*Temp. of milk from water section °F.*	*Temp. of milk from D.E.R. cooler °F.*
Aug. 1937.	36	22½	72	76	90	80	50
Sept. 1937.	36	22½	65	75	90	78	48
Sept. 1938.	48	40	70	75	90	78	55
Dec. 1938.	60	42	45	60–61	88–90	64–66	47–49
Jan. 1939.	60	42	46	61–62	85–88	65–67	49–57

It is seen from the above that the D.E.R. cooler has been of practical advantage to the producer in maintaining low temperatures in market milk. As milk is only delivered once daily (morning's only) the merits of the cold storage chest are readily recognised. Pint bottles of evening milk at 45°F. kept in the dairy gave a morning temperature of 51°F whilst storing in the cold chest gave a morning temperature of 42°F.

TABLE VII.

Comparison of the bacteriological content of milk cooled (a) with ordinary farm water cooler and (b) with direct expansion refrigerator cooler.

Summer months 1937 and 1938.

All samples from morning milk tested 28 hours after milking.

Series.	*Period of sampling.*	*No. of samples.*	†*Temp °F.*		**Colony Count per ml.*	*Coliform organisms content.*		†*Methylene Blue reduction.* (*Hours.*)	
			On farm.	*Arr. at lab.*		**Count per ml.*	*% positive* (+ *1/10* ml.)	*37°C.*	*15°-17° C.*
Water cooled by means of ordinary farm cooler sterilised in steam chest	June to July 1937.	20	70°	67°	121,000	10	40	4.1	24
Water cooled over upper part of D.E.R. cooler, washed with detergent.	Aug. to Sept. 1937.	15	71°	66°	870,000	103	60	2.7	12
Cooled over D.E.R. cooler washed with detergent.	Aug. to Sept. 1937.	15	58°	64°	170,000	47	64	3.1	24
Cooled over D.E.R. cooler steamed 15 mins. in covers.	June to Sept. 1938.	32	58°	60°	19,000	3	22	7.7	48

D.E.R.—direct expansion refrigerator cooler. †—arithmetic means. *—geometric means.

The bacteriological quality of samples of milk taken from the cooler under various circumstances was studied and the results of a series of experiments are given in Table VII. Morning's milk cooled to 70°F. by means of the ordinary farm cooler during June and July gave a fairly high colony count and a low methylene blue reduction time. A further series of samples were taken during August and September when the D.E.R. cooler was in use. The latter was being cleaned at this time by means of hot detergent solutions. The samples comprising this second series were taken from the upper portion of the D.E.R. cooler, the milk being only cooled with water. The cooling process was thus comparable to that carried out with the ordinary farm cooler except that the latter was being sterilised in a steam chest for 15 — 20 minutes. The considerable difference in bacteriological results can be attributed to the inefficient methods of cleansing and sterilisation used for the permanently fixed D.E.R. cooler. The third series of samples, taken after the milk has been run over both upper and lower portions of the D.E.R. cooler and cooled to 55° — 60°F. still gave bacteriological results slightly poorer than those obtained with the original steam sterilised cooler. A fourth series of 32 daily samples taken from the D.E.R. cooler during June to September 1938, when it was being efficiently steam sterilised, show a marked improvement in quality. The mean colony count was now under 20,000 per ml. ; very few coliform organisms were detected ; methylene blue was not reduced within 7 hours, and the keeping quality of the milk from the time of production was over 3 days. These results demonstrate quite clearly that unless the D.E.R. unit is efficiently steam sterilised, the improvement in milk quality which is to be expected as the result of better cooling, is nullified by bacterial contamination from its surface.

The results of a further series of samples taken from both morning and afternoon milk during summer, when the D.E.R. cooler was being partially sterilised by means of hot detergent and cold water are given in Table VIII. Uncooled samples were also taken for comparison. The three series of morning's milk samples ; uncooled, water cooled to 71°F. and D.E.R. cooled to 55°F., show a progressive improvement in hygienic quality. Even the milk cooled to 55°F did not attain the bacteriological standards for designated raw milk. This proves that really good cooling during warm weather does not neutralise the effect of bacterial contamination from an unsterile utensil.

Afternoon milk cooled by the D.E.R. cooler to 55°F., kept at atmospheric temperature in the farm dairy overnight and examined the following morning on delivery, attained designated milk stan-

TABLE VIII.

Cooling with D.E.R. cooler during August—September 1937. Cooler washed with hot detergent but not steam sterilised.

Series of morning and afternoon milk samples taken after cooling	*No. of Samples*	*Age on exam. (Hrs.)*	†*Mean temp. °F.*		**Colony count per ml. Milk agar 3 days. at 37°C.*	*Coliform organisms content.*		**Methylene blue reduction (Hours.)*	
			At farm	*On arr. at lab.*		**Mean count per ml.*	*%positive (+1/10 ml.)*	*37°C.*	*15°-17°C.*
Uncooled *morning's* milk held for 24 hours at 60°—65°F.	20	28	94°	72°	2,260,000	2,000	75	2.4	14
Water cooled *morning's* milk from upper part of cooler, held for 24 hours at 60°—65°F.	20	28	71°	66°	870,000	103	60	2.7	23
D.E.R. cooled *morning's* milk held for 24 hours at 60°—65°F.	20	28	55°	63°	270,000	47	60	3.1	24
D.E.R. cooled *afternoon's* milk kept at atmospheric temperature in farm dairy overnight.	15	17	63°	65°	30,000	5	29	5.8	30
D.E.R. cooled *afternoon's* milk kept at 43°—47°F. in farm refrigerator overnight.	15	17	45°	59°	2,000	0	0	8.7	43

† Arithmetic means. *Geometric means.

dards and kept sweet for 48 hours. Afternoon milk held in the farm cold storage chest at 45°F. and examined the following morning on delivery gave exceptionally good bacteriological results and kept sweet for 60 hours. The mean colony count of this series was under 3,000 per ml.

A fairly extensive investigation of the efficiency of the D.E.R. cooler when it was being steam sterilised for 15 minutes with the covers on, was carried out during the four warmest months of 1938. (Table IX). The morning's milk examined within four hours of milking, and thus representative of its quality on delivery to the consumer, gave exceptionally good bacteriological results. The colony count was under 5,000 per ml. and methylene blue was not reduced within 8 hours. Holding at 45° — 55°F. for 24 hours resulted in a slight increase in both colony counts and coliform organisms but had no serious effect on methylene blue reduction and keeping quality. When the morning's milk was held for 24 hours at 65° — 70°F, the usual atmospheric temperatures for this time of year, the quality was seriously affected.

The fourth and fifth series were arranged so that the holding of afternoon's milk overnight at atmospheric temperatures and in the farm cold storage chest might be compared. The milk was cooled to 55°F. by means of the D.E.R. cooler, the 8 ounce samples were kept for 14 hours in the farm dairy or in the farm chest at 50° — 55°F. compared with a temperature of 43° — 47°F. during August and September of 1937.

It is significant that both the bacterial content and the keeping quality of the afternoon milk held overnight in the refrigerator are slightly better than the results for the morning milk tested within four hours of production. It is thus possible for producer-retailers to deliver afternoon's milk on their usual morning round actually superior in keeping quality to the milk produced that morning. The value of the D.E.R. cooler combined with a refrigerator is very evident in such circumstances.

The results of the bacteriological examination of samples taken during winter months (December-February) when the D.E.R. cooler was being efficiently steam sterilised are given in Table X. Both morning and afternoon milk samples were held before examination in accordance with the conditions prescribed by the Ministry of Health Memorandum, 1937, for designated milk. The results are exceptionally good, the keeping quality from the time of production ranging from 3½ to 4½ days. The farm refrigerator was regulated to operate at 50°F. during this period so that the slightly better results recorded for the morning milk may be due to the fact that it was held overnight in the laboratory refrigerator at 32° —

TABLE IX.

Cooling with D.E.R. cooler during June—September, 1938. Cooler steam sterilised for 15 min. in covers.

Series of morning and afternoon milk samples taken after cooling.	*No. of samples.*	*Age on exam. (Hours.)*	*†Temp. on testing °F.*	**Colony count per ml. Milk agar 3 dys. at 37°C.*	*Coliform organisms content.*		*†Methylene blue reduction (Hours.)*	
					**Mean count per ml.*	*% positive (+1/10 ml.)*	*37°C*	*15°-17°C.*
Morning's milk examined on delivery	32	4	61°	4,700	2	19	8.3	54
Morning's milk held for 24 hours at 45°—55°F, in ice chest in laboratory.	32	28	50°	19,000	3	22	7.7	48
Morning's milk held for 24 hours at 65°—70°C. (atmospheric temperature) in laboratory.	32	28	67°	215,000	145	70	4.0	35
Afternoon's milk held overnight at atmospheric temperature in farm dairy.	32	17	65°	28,000	1	6	7.5	48
Afternoon's milk held overnight in farm refrigerator at 50°—55°F.	32	17	60°	8,000	2	12	8.6	55

† Arithmetic means. * Geometric means.

40°F. The afternoon samples taken during this time give bacteriological results only slightly superior to those obtained from similarly treated summer samples.

TABLE X.

Cooling with D.E.R. cooler during winter months, December - February.

Cooler steam sterilised for 15 minutes in covers.

Milking.	*No. of samples.*	*Age on exam. (Hours.)*	† *Temp. on arr. at Lab. °F.*	**Colony Count per ml. Milk agar 3 days 37°C.*	**Coliform organisms content. Per cent. positive (+ 1/10 ml)*	† *Methylene blue reduction. (Hours).*	
						37° C.	*15°-17°C*
1. Morning milk.	30	28	47°	7,310	3	9.1	68
2. Afternoon milk	30	17	48°	8,000	0	8.7	62

(1) Morning milk kept at atmospheric temperature for twelve hours and then held at 32° – 40°F in laboratory refrigerator overnight.

(2) Afternoon milk kept in farm refrigerator overnight and examined on arrival at laboratory the following morning.

† Arithmetic means.
* Geometric means.

Summary.

(1) Holding good quality milk at 40°F. for 24 hours improved its bacteriological quality. Holding at 60°F. for the same time resulted in a twenty-fold increase in colony count, a thousand fold increase in coliform organisms content, failure of the samples to attain the methylene blue reduction standard for designated milk and a very marked reduction in keeping quality. Holding at 70°F. for 24 hours led to the complete spoilage of the milk.

(2) A comparison of water cooling to 70°F. with an ordinary farm cooler and to 55°F. with a direct expansion refrigerator cooler showed that when both were thoroughly steam sterilised the latter gave much improved bacteriological and keeping quality results.

(3) If the D.E.R. cooler was not efficiently sterilised the milk was so contaminated by the organisms from its surface that the bacteriological results were inferior to those obtained by water cooling to 70°F. with a steam sterilised cooler.

(4) It was found that steaming the cooler for 15 minutes with the covers on resulted in satisfactory sterilisation.

(5) Afternoon's milk cooled by the D.E.R. cooler during summer months to 55°F. and held overnight in the farm refrigerator at 45° — 55°F. was superior in quality on delivery to the consumer, to morning's milk produced four hours previously.

(6) The efficiency of the D.E.R. cooler depends upon :—

(a) The quantity and temperature of the water flowing through the cooler.

(b) The rate of flow of milk over the cooler. Unfortunately there is no satisfactory arrangement for controlling the milk flow on the plant under consideration.

(c) The ease with which the cooler can be cleaned. A fixed cooler is not considered suitable.

REFERENCES.

AYERS, H. S. and CLEMMER, P. W. (1918) *U.S.D.A. Bull.* 739.
——— COOK, L. B. and CLEMMER, P. W. (1918) *U.S.D.A., Bull.* 642.
FRAYER, J. M. (1930) *Vermont Agr. Exp. Sta. Bull.* 313.
——— (1932) *Vermont Agr. Exp. Sta. Bull.* 343.
FINKELSTEIN, R. (1919) *J. Dairy Sc.*, 2, 460.
HASTINGS, E. G. (1922) "Microbiology" Ed. by C. E. MARSHALL. 3rd Ed. CHURCHILL, London.
HUNTER, O. W. (1919) *J. Dairy Sc.*, 2, 108.
MEMORANDUM (1937) *Min of Hlth. Memo.* 139/Foods. H.M.S.O.
PARK, W. H. (1901) *J. Hyg.*, 1, 391.
PROVAN, A. L., DUDLEY, F. J. and THOMAS, S. B. (1936), *Welsh J. Agric.*, 12, 130.
SHERMAN, J. M. and WING, H. V. (1933), *J. Dairy Sc.*, 16, 165.
STENHOUSE, WILLIAMS, R., MATTICK, A. T. R., and HOY, W. A. (1924) *Proc. 4th Int. Cong. of Refrigeration Comm.* 7.

METHYLENE BLUE REDUCTION OF DUPLICATE SAMPLES OF RAW MORNING'S MILK HELD OVERNIGHT AT 40°F. AND 60°F.

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The grading of tuberculin tested and accredited milk has been carried out in this country by means of the modified methylene blue test and the coliform test, since January 1937. The Ministry of Health regulations (Memorandum 1937) prescribe that morning's milk samples must be kept at atmospheric temperature until 6 p.m. and then held in a refrigerator (32° — 40°F.) until 10 a.m. the following morning, when the tests are set up.

The present investigation has been carried out in order to determine the effect of storage of samples overnight at 60°F. as compared with 40°F.

Ellenberger and Moody (1930) found that icing samples for two hours shortened the methylene blue reduction time by 16 minutes. Frayer (1930) compared the reduction time of raw milk examined immediately after sampling and after being held at 40°F. for 24 hours. He found that refrigeration increased the reduction times of poor quality milk by 9 minutes and good quality milk by 29 minutes. Wilson (1935) found that, on the average, the reduction time of samples of Grade A and raw churn milk, iced for 18 — 24 hours, was 5 — 10 minutes longer than that of the controls which were tested immediately on arrival at the laboratory.

More recent work by Malcolm and Leitch (1936) Thomas and Tudor (1937), Thomas and Hobson (1938) and Advisory Dairy Bacteriologists (1938) has shown that holding samples at 40°F for 16 — 17 hours, during winter months has a marked retarding effect on methylene blue reduction.

Technique used.

Official samples of tuberculin tested and accredited milk were used for the experiment. Morning milk samples arrived in the laboratory during the afternoon of the day of production. They were kept at atmospheric temperatures until 5 p.m., and then after mixing thoroughly, were divided into two portions. One was placed in a refrigerator at 40° ± 2°F., whilst the other portion was held in an incubator at 60° ± 2°F. The samples were tested the following morning at 9 a.m. when they had been incubated or refrigerated for 16 hours. Methylene blue tests were carried out according to the technique prescribed by the Ministry of Health (Memorandum 1937.).

Results.

One hundred and twenty samples were tested during winter, and another 150 during summer. (Table I.)

TABLE I.

Mean methylene blue reduction times for the nine series of samples tested.

Group.	*Number of Samples*	*Date of examination (1937-8.)*	*Mean temp. of milk on arrival at laboratory °F.*	*Mean reduction time (Hrs. & Mins.)*		*Mean difference. Hours & Minutes*
				Samples held overnight at 40°F.	*Samples held overnight at 60°F.*	
I	30	Nov. 8–12	54°	8.44	4.26	+4.18
II	30	„ 15–19	56°	7.45	3.47	+3.58
III	30	Dec. 1–6	55°	8.13	4.53	+3.20
IV	30	„ 9–14	45°	9.06	7.13	+1.53
Total.	120	—	52°	8.27	5.05	+3.22
V	30	July 1	66°	4.47	1.35	+3.12
VI	30	„ 15	65°	5.46	1.15	+4.31
VII	30	„ 29	67°	5.25	2.10	+3.25
VIII	30	Aug. 19	70°	4.18	1.41	+2.37
IX	30	Sept. 18	65°	6.11	1.35	+4.36
Total	150	—	67°	5.17	1.39	+3.38
Grand Total	270	—	—	6.41	3.10	+3.31

The winter and summer series include data which vary from samples arriving at the laboratory during December at 45°F., with a mean reduction time after refrigeration of 9 hours 6 minutes, to August samples arriving at 70°F. with a mean reduction time of 4 hours 18 minutes.

The mean reduction time after refrigeration of the winter samples was 8 hours 27 minutes, and of the summer samples 5 hours 17 minutes. Refrigeration as compared with holding at 60°F resulted in an increase of 3 hours 22 minutes reduction time for the winter samples and 3 hours 31 minutes for the summer samples.

It might be expected that good quality milk should show higher differences in reduction time than poor quality milk, though the above comparison of winter and summer results does not show any indication of this. The results have therefore been arranged in increasing reduction time frequency groups. (Table II.). The differences in reduction time show a gradual increase from 54 minutes up to 4 hours 20 minutes but then shows a decrease with samples having reduction times in excess of 8 hours. One abnormal sample took 26½ hours to reduce methylene blue after holding overnight in the refrigerator but after holding at 60°F. it reduced the dye in 14 hours.

TABLE II.

Relation between quality of milk and influence of storage at 40° and 60°F on reduction time.

Class intervals in hours.	*Held overnight at 40° F.*		*Held at 60° F. Mean reduction time (Hours & mins)*	*Mean difference in reduction time (Hours and mins.)*
	No. of Samples.	*Mean reduction time (Hours & mins)*		
0.5–2.0	35	1.15	0.21	+0.54
2.5–4.0	17	3.10	0.39	+ 2.31
4.5–6.0	54	5.17	1.07	+4.10
6.5–8.0	75	7.19	2.59	+4.20
8.5–10.0	75	9.11	5.22	+3.49
10.5–12.0	13	11.19	8.55	+2.33
Over 12 hrs.	1	26.30	14.00	+12.30

The results show that remarkably high differences in reduction times are common. Only five samples showed the same reduction time after holding at the two different temperatures. Twelve per cent. gave a difference of over 6 hours, and as many as 36 per cent. a difference over 4 hours (Table III.).

TABLE III.

Frequency distribution of differences in reduction times between samples held at 40° and 60°F.

Difference in reduction times. (Hours and minutes).	*Number of samples.*	*Per cent.*
0	5	1.9
0.30–2.00	83	30.7
2.30–4.00	84	31.1
4.30–6.00	66	24.5
6.30–8.00	30	11.1
Over 8 hours.	2	0.7

Previous to 1937 it was the practice at this laboratory to place all milk samples, on arrival at the laboratory, in a 60°F. incubator. Morning milk samples were held overnight at this temperature and examined the following morning when 28 hours old. Of 11,053 morning's milk samples taken during the course of Clean Milk Competitions and Advisory Schemes and treated as above, 62 per cent. gave colony counts on standard agar, after incubating for 2 days at 37°C., under 100,000 per millilitre, and 73 per cent. did not show the presence of coliform organisms in 1/100 ml. milk. A good proportion thus attained Grade A standards after holding overnight at 60°F. A comparison of the grading of the duplicate samples according to the modified methylene blue test is given in Table IV. When the milk was held at 40°F. overnight, 11 per cent. of the winter samples and 40 per cent. of the summer samples failed to attain the prescribed standards.

Holding at 60°F. had a marked effect on the grading ; 52 per cent. of the winter samples and 95 per cent. of the summer samples failing. The rapid increase in the number of designated milk producers during the last two years has coincided with a serious deterioration in the hygienic quality of accredited and tuberculin tested milk, as these results show.

TABLE IV.

Proportion of samples failing to attain the Methylene Blue standards prescribed for designated raw milk.

Season.	*No. of samples examined*	*Methylene Blue reduction standards for Accredited Milk*	*Samples failing to attain Methylene Blue standards.*			
			After holding overnight at 40°C.		*After holding overnight at 60°C.*	
			Number	*Per cent.*	*Number*	*Per Cent.*
Winter (Nov-Dec.)	120	5½ hours.	13	10.8	62	51.7
Summer (July-Sept)	150	4½ hours	60	40.0	142	94.6
Total	270	—	73	27.0	204	75.5

Discussion.

It is suggested that holding samples overnight at 60°F. is more representative of actual conditions in the consumers home than holding at 40°F. It may be argued that holding at 40°F. gives results that are a better index of the quality of the milk as it leaves the farm, and that holding overnight at 60°F. during summer leads to a rapid increase of certain organisms, such as the coliform and lactic acid groups, which have a strong reducing action on methylene blue. On the other hand holding at 40°F during cold winter weather has a marked retarding effect on the reduction time.

Efficient farm cooling reduces the temperature of the milk to 50° — 55°F. even during summer and it may be found that holding the samples, both during transport and on arrival at the laboratory, at this temperature will be the most suitable method to adopt for the treatment of official samples of designated milk.

It should be possible to obtain insulated containers that will keep the samples within a few degrees of the temperatures of sampling for a period of 6 — 8 hours, which generally covers the period of transport to the laboratory. Producers who cool their milk efficiently will thus, obtain due credit whilst poorly cooled milk will fail to attain the designated standards during summer.

On arrival at the laboratory the samples could be placed immediately in an air circulating incubator and held at 50° — 55°F. until convenient for testing at a standard age.

Summary.

(1) One hundred and twenty winter samples and one hundred and fifty summer samples of mornings' milk were tested in duplicate by means of the Methylene Blue reduction test after holding overnight at 40° and 60°F. respectively.

(2) The portions held at 40°F. gave an average reduction time 3½ hours longer than that for the duplicates kept at 60°F.

(3) The mean differences in reduction time increased from 54 minutes in the case of samples reducing within 2 hours after holding at 40°F., to 4 hours 20 minutes in the case of samples being reduced within 6½ — 8 hours.

(4) Holding at 40°F. during winter has a retarding effect on methylene blue reduction and in addition is considered to be too lenient a treatment for market milk samples during this period. Holding at 60°F. on the other hand seems to be too drastic a treatment during summer months for the quality of designated raw milk that is now being produced in this country.

(5) It is suggested that since efficient farm cooling reduces the temperature of the milk to 50° — 55°F. even during the warmest weather, samples should be placed in an incubator held at this temperature immediately on arrival at the laboratory. Samples should be sent to the laboratory in well insulated containers, capable of keeping the temperature of the milk within a few degrees of the sampling temperature.

REFERENCES.

ADVISORY DAIRY BACTERIOLOGISTS (1938)*Agri. Res. Council Rep.* No. 3. p. 76.

ELLENBERGER, H. B. and MOODY, R. I. (1930) *Vermont Agri. Exp. Sta. Bull.* No. 312.

FRAYER, J. M. (1930) *Vermont Agri. Exp. Sta. Bull.* No. 313.

MALCOLM, J. F. and LEITCH, R. H. (1936) *Scott. J. Agri.*, 19, 321.

MEMORANDUM (1937) *Min. of Hlth. Memo.* 139/Foods.

THOMAS, S. B., and HOBSON, P. M. (1938) *Welsh J. Agri.*, 14, 247.

——————, TUDOR, J. A. (1937) *Welsh J. Agri.*, 13, 308.

WILSON, G. S. ET AL. (1935) *Med. Res. Council Spec. Rep.* No. 206, p. 276.

A COMPARISON OF DIFFERENT METHODS OF PERFORMING THE METHYLENE BLUE TEST.

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Since Neisser and Wechsberg (1900) first used methylene blue reduction as an indicator of the hygienic quality of milk, numerous contributions by European and American investigators have dealt with its value for milk grading. The technique devised by Barthel and Orla Jensen (1912) has been used on the Continent and in this country, whilst a standard technique suggested by the American Public Health Association (1934) has been popular in the United States and Canada.

Wilson et al. (1935) recommended a modified test, the main feature of which is the inversion of the tubes at half-hourly intervals. This has been adopted in England and Wales as one of the official tests for the grading of designated raw milk (Memorandum 1937).

Wilson and his co-workers (1935) compared the old and modified methods of performing the test. They found that with good quality raw milk, there was a very considerable diminution in the reduction time by the new method, whilst the end point was easier to determine.

Frayer (1937) compared the old and modified tests, using fifty to a hundred replicates. He found that the modified test gave shorter and significantly more reliable reduction times than the old method. Thornton (1937) during the examination of 335 milk samples, found that the modified test gave little difference in reduction times as compared with the American standard test up to three hours, but in the medium and better class samples there was a material decrease in the mean reduction times due to the inversion of the tubes. Johns (1938) states that the accuracy of the methylene blue test is greatly increased by periodical inversion of the tubes during incubation. In addition, reduction time is generally shortened and the decolourisation is more uniform, especially with the better grades of milk, and he believed that these advantages more than compensate for the slight inconvenience entailed by the modification.

Technique of present work.

The technique prescribed by the Ministry of Health (Memorandum 1937) was employed for the modified test, whilst the old test was carried out with the same size of tubes, 10 ml. of milk and the same methylene blue solution. The tubes in the latter case were plugged with cotton wool and were only inverted once before incubating. Both batches were incubated in the same water bath at a temperature of 37° — 38°C. The tubes for the modified test were examined and inverted half-hourly, whilst the tubes for the old method were only examined at this time. Control tubes as prescribed in the Ministry of Health Memorandum were set up with each batch.

The samples consisted of morning's accredited and tuberculin tested milk. They arrived at the laboratory during the afternoon of the day of production and were placed in a refrigerator at 40°F. at 5 p.m. and examined at 10 a.m. the following morning. One hundred and forty-six samples were examined during cold weather (December-January) and another group of 155 samples tested during warm weather, (August-September).

Results.

A comparison of the results obtained with the winter and summer samples is given in Table I., whilst the influence of the grade of milk on the differences in reduction time is shown in Table II.

TABLE I.

Comparison of results obtained with winter and summer samples.

	Number of Samples.	*Mean reduction time in hours and minutes.*		*Difference due to inversion (Hours and minutes.)*
		Old method (No inversion).	*Wilson's method (Half-hourly inversion)*	
Winter	146	13.50	8.41	-5.09
Summer	155	4.03	3.24	-0.39

It will be observed that there was a diminution of over 5 hours in the mean reduction time of the winter samples tested by the modified method, whereas the corresponding decrease in the case of poor quality summer samples was only 39 minutes. The modified technique results on the average in little difference up to 4 — 5 hours and may even cause an increased reduction time in the poorest quality milk, due possibly to the incorporating of oxygen during the

TABLE II.

Influence of quality of milk on difference due to inversion.

Class intervals in hours. (Old method.)	*Number of samples.*	*Mean reduction time in hours and minutes.*		*Difference due to inversion. (Hours and minutes.)*
		Old Method (No inversion.)	*Wilson's method (Half hourly inversion.)*	
0—1½	71	0.45	0.51	+0.06
2—3½	16	2.45	3.02	+0.17
4—5½	15	4.52	4.32	—0.20
6—7½	24	6.46	5.38	—1.08
8—9½	38	8.37	6.26	—2.11
10—11½	29	10.55	8.01	—2.54
12—13½	33	12.55	8.44	—4.11
14—15½	27	14.47	8.49	—5.58
16—17½	27	16.26	9.57	—6.29
18—19½	16	18.41	10.24	—8.17
20—21½	3	20.10	10.30	—9.40
22—23½	1	22.00	12.00	—10.00
24—25½	1	24.00	11.00	—13.00
Total	301	9.21	6.00	—3.21

inversion just prior to reduction of the dye. In this connection it may be noted that tubes which appeared to be near the end point were not inverted. Thornton (1937) observed a similar phenomenon, hardly any difference being observed up to 2 — 3 hours and a increased mean reduction time being recorded for the 0 to 1 hour standard reduction time, class interval group.

The difference due to inversion shows a gradual increase coincident with the improvement in the quality of the samples, the better quality milk being decreased in reduction time by as much as 4 — 10 hours.

Summary.

(1) A comparison of the old and the Wilson modification of the methylene blue test was carried out with 301 samples of raw designated milk.

(2) The modified technique gave little mean difference in reduction time from the old method, for samples reducing within 5½ hours.

(3) A very slight mean increase in reduction time was obtained with the modified test in the case of the poorer quality samples which reduced within 3 hours.

(4) The modified test however resulted in a marked decrease of reduction time in the better quality milk samples.

REFERENCES.

AMERICAN PUBLIC HEALTH ASSOCIATION (1934) " Standard Methods of Milk Analysis" *Amer. Publ. Hlth. Ass.* N. York, 6th. Ed.
BARTHEL, C., and ORLA JENSEN (1912) *Milchw. Zbl.*, 41, 417.
FRAYER, J. M. (1937) *Vermont Agr. Expt. Sta. Bull.* No. 424.
JOHNS, C. K. (1938) *J. Dairy Sc.*, 21, 227.
MEMORANDUM (1937) *Min. of Hlth. Memo.*, 139/Foods (Jan. 1937.) H.M.S.O., London.
NEISSER, M., and WECHSBERG, F. (1900) *Munch. med. Wschr.*, 47, 1261.
THORNTON, H. R. (1937), *J. Dairy Sc.*, 20, 693.
WILSON, G. S. ET AL. (1935) *Med Res. Council. Spec. Rep.* Series No. 206, p. 280.

THE VARIABILITY OF THE METHYLENE BLUE TEST.

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It is claimed that the modified methylene blue test gives more reliable reduction times due to the more uniform distribution of butter fat and bacteria. Grimes, Barnett and Reilly (1927) showed that with the old method, the longer the reduction time the greater the variation between duplicate or triplicate determinations. Thornton and Hastings (1930) observed serious variations in the reduction times of replicate tubes of milk tested by the old method. These variations tended to increase with the reduction times, so that they did not consider the test reasonably accurate after the 5½ hour period. Fay (1930) also measured the error of the test as then performed, by putting up a large number of tubes from each sample of milk. Most of the individual coefficients of variation obtained by him were under 5 per cent.

Wilson et al. (1935) reported on an experiment with the modified test. Thirty-five samples of milk having a mean reduction time of 3 hours 55 minutes, were examined by each of four workers using the same water bath. Readings were taken at frequent intervals which were less than half an hour. The mean of the coefficients of variation was 1.1 per cent. They point out that the total error of the test calculated in this way is very small. It should be observed however that their results were obtained with a comparative small series of low grade milk samples.

Thornton (1937) concluded that replicate samples of good milk frequently exhibit serious variations of standard (old) reduction times, which increase in magnitude and frequency as the reduction time increases. He observed that these variations practically disappeared if the tubes were shaken during incubation.

Frayer (1937) compared different methods of conducting the test, 50 — 100 replicate tests of each sample of milk being made. He found that the Wilson modification resulted in a significantly more reliable reduction time. The average coefficient of variability obtained with the standard American method was 4.32 per cent compared with 0.20 per cent. obtained with the modified test.

The experiments described in this article were carried out with samples of accredited and tuberculin tested milk. They were taken from morning's milk and kept at atmospheric temperatures until 5 p.m. on the day of sampling when they were placed in a 40°F. refrigerator. They were taken out of the refrigerator at 10 a.m. the following morning and tested immediately by the modified test.

Varations in duplicate tubes examined by one worker.

A series of 265 samples tested regularly over a period of one year according to the technique prescribed by the Ministry of Health (Memorandum 1937), were set up in duplicate in the same water bath and examined and inverted half hourly by one worker. No variations were observed in any of the samples reducing within 5 hours, but as the reduction times increased the variations increased in number and magnitude (Table I). These variations are much lower than those recorded by Thornton (1937) during a similar experiment with the American standard method.

TABLE I.

Variation in duplicate tubes examined by one worker.

Class intervals in hours and mins.	*Number of Samples.*	*Samples showing variation in duplicate tubes.*		*Maximum variation. Hours and minutes.*	*Mean Variation. Hours and minutes.*
		Number	*Per Cent.*		
0.30— 2.00 ……	10	0	0	0.00	0.00
2.30— 4.00 ……	16	0	0	0.00	0.00
4.30— 6.00 ……	26	3	11	1.00	0.04
6.30— 8.00 ……	87	12	14	1.00	0.05
8.30—10.00 ……	108	22	20	1.00	0.07
10.30—12.00 ……	18	6	33	1.00	0.15

Variations in quintuplicate tubes examined by one worker.

Sixty-three samples were tested in quintuplicate by one worker during winter and spring. The tubes were examined and reduction recorded at five minute intervals, but they were inverted half-hourly. The technique was otherwise strictly according to that prescribed by the Ministry of Health. (Memorandum 1937).

The majority of the samples were of high grade milk with reduction times in excess of 6 hours; the mean reduction time for the series being approximately 8 hours. (Table II). Seven samples (11 per cent.) showed no variation in reduction time, whilst the mean of the maximum variations obtained with the remaining 56 samples was 11 minutes. The mean coefficient of variation is under 1 per cent. The variations are so low under these conditions of testing that no increasing trend, as expressed by maximum variation and standard variation, can be observed with increase of reduction time.

TABLE II.

Variations in quintuplicate tubes examined by one worker.

Methylene blue reduction times (minutes).		*Number of Samples.*	*Mean maximum variations (Minutes)*	*Mean standard deviations (Minutes)*	*Mean coeffici-ients of variation (Per cent)*
Class intervals	*Mean*				
5—120	-	–	—	—	—
125—240	157	3	5.0	2.16	1.54
245—360	290	5	13.0	4.52	1.62
365—480	424	17	6.3	2.50	0.59
485—600	530	23	6.2	2.74	0.59
Over 600	649	15	18.0	6.12	0.90
Total	482	63	9.5	3.49	0.88

Varations in reduction times obtained by four separate workers.

A series of 111 samples taken during December—January and another of 153 samples taken during August—September were examined by four workers using separate water baths. The samples were well mixed and put up at the same time. The same methylene blue solution was used and the baths were carefully adjusted between 37° and 38°C. The difference between the temperatures of the four baths was at no time found to exceed 0.5°C. Readings were taken every half hour. The four workers had at least six months' experience of the test under routine conditions. The main object of this experiment was to ascertain the total error of quadruplicate testing under routine conditions. The results are given in Table III. The winter and summer groups differ widely in quality, the mean reduction time for the former being 9 hours 7 minutes, and for the latter 3 hours 55 minutes. The average of

TABLE III.

Comparison of reduction times obtained by four separate workers.
(All reduction times given in hours and minutes).

Season.	*Number of Samples.*	*Mean reduction times in hours and minutes.*				*Mean of all tests.*	*Mean of maximum variations.*	*Mean of standard deviations (Hours and minutes.)*	*Mean of coefficients of variation (Per Cent.)*	*Maximum coefficient of variation (Per Cent.)*
		Worker A.	*Worker B.*	*Worker C.*	*Worker D.*					
Winter. (Dec.—Jan.)	111	9.30	8.52	8.58	9.15	9.07	1.23	0.24	6.5	36.5
Summer. (Aug.—Sept.)	153	4.07	3.53	3.49	3.53	3.55	0.46	0.19	8.6	35.3

the maximum variations was as high as 1 hour 23 minutes for the good quality samples but was only 46 minutes for the summer samples. The mean of the standard deviations is also higher for good quality milk, but when the variation is expressed on a percentage basis by coefficients of variation very little difference can be found between the two groups of samples.

It is interesting to note that Worker A regularly reported reduction times longer than those obtained by the other three workers. The results were summarized and treated statistically at the end of every day's work and the workers were thus aware of this fact from the commencement of the experiment.

The results of the summer group are similar in hygienic quality and mean reduction time to those recorded by Wilson et al. (1935) but the variations are much higher than those obtained by the London workers.

When the results are arranged according to the frequency distribution of the maximum variations (Table IV), it is observed that 51 samples (19 per cent.) were reported as reducing at the same time by all workers. Forty-four of these results however were obtained during the examination of the poor quality summer samples. The table shows quite clearly that higher variations were obtained with the high grade winter samples; 17 per cent. of the winter samples as compared with 4 per cent. of the summer samples gave maximum variations over 2 hours. Similarly, 51 per cent. of the former and 23 per cent. of the latter had maximum variations in excess of one hour. Two winter samples gave abnormally high variations of 4 and 6 hours respectively.

Table IV.

Frequency distribution of maximum variations.

Maximum variations in hours and minutes	*Winter samples*		*Summer samples*		*Total*	
	No.	%	*No.*	%	*No.*	%
0.00	7	6.3	44	28.7	51	19.3
0.30	25	22.5	44	28.7	69	26.1
1.00	22	19.8	30	19.6	52	19.7
1.30	28	25.2	20	13.0	48	18.2
2.00	10	9.0	9	5.9	19	7.2
Over 2 hours	19	17.1	6	4.0	25	9.4
TOTAL	111	99.9	153	99.9	264	99.9

The frequency distribution of the coefficients of variation given in Table V, shows that a considerable number of high variations were recorded; the C.V. for 70 samples being over 10 per cent., whilst 26 samples varied by more than 16 per cent.

Table V.

Frequency distribution of the coefficients of variation.

Coefficients of variation class intervals (%)	*Samples*	
	Number	*Per Cent.*
0.0—2.0	55	21
2.1—4.0	47	18
4.1—6.0	29	11
6.1—8.0	42	16
8.1—10.0	21	8
10.1—12.0	17	6
12.1—14.0	17	6
14.1—16.0	10	4
Over 16 per cent.	26	10
Total	264	100

The results for 262 samples are arranged in class intervals according to increasing reduction times in Table VI. The maximum variations as well as the standard deviations show a gradual increase with improvement in the quality of the milk and increasing reduction times. From the point of view of the practical application of milk grading by means of methylene blue reduction, it is well to realise that under the conditions of this experiment, mean maximum variations of practically one hour were obtained with samples reducing within 3 — 6 hours.

Table VI.

Variations in reduction time according to quality of milk.

Reduction time class intervals in hours and minutes	*Number of samples*	*Means of:—*	
		Maximum variations (Hours and Minutes)	*Standard deviations (Hours and Minutes)*
0.30— 2.00	52	0.20	0.07
2.30— 4.00	29	0.55	0.23
4.30— 6.00	37	0.47	0.20
6.30— 8.00	53	1.18	0.31
8.30—10.00	63	1.16	0.35
Over 10 hours	28	1.21	0.33
Total	*262	—	—

*Two samples with abnormally high variations omitted.

Discussion.

A comparison of the data obtained during the course of different investigations dealing with the reliability of the modified methylene blue test is given in Table VII. It will be observed that the variations obtained during the first three investigations are very low. In the first two the tests were carried out by one worker whilst

TABLE VII.

Coefficients of variation for replicate tests by the modified method according to various investigations.

Investigation	*Replicates*	*No. of samples tested*	*Mean Reduction time (hours and minutes)*	*Maximum coefficient of variation (Per Cent.)*	*Mean coefficient of variation (Per cent.)*
1. Frayer (1937)	50—100 replicate tests of each sample.	20	5.08	2.0	0.3
2. Present investigation	Quintuplicate tests of each sample.	63	8.02	5.1	0.9
3. Wilson *et al* (1935)	Four workers.	35	3.55	16.6	1.1
4. (Summer). Present investigation	Four workers.	153	3.55	35.3	8.6
5. (Winter). Present investigation	Four workers.	111	9.15	36.5	6.5
6. Provan *et al* (1937)	Duplicates at each of four laboratories.	23	5.03	53.5	9.4

Wilson and his four workers dealt with low grade milks. It is also significant that Frayer examined the tubes at 15 minute intervals, Wilson et al. at unstated frequent intervals, which were less than half hourly, whilst in the second investigation they were examined at 5 minute intervals. In investigations 3 to 6 the test was carried out under routine conditions by four workers, the tubes being examined at half hourly intervals. Eight replicates were set up in the case of the last investigation under consideration.

It would appear that the variations observed depend on intervals between examination, grade of milk used during the investigation, and to some degree on the personal factor. It is significant that the results of two types of investigation carried out in our laboratory (Nos. 2 and 5) differ to a marked degree. One worker, using the same apparatus and methylene blue solution as the four workers obtained a much lower variation with quintuplicate tests than the latter. The milk samples were obtained from the same source, under the same conditions and were approximately of the same quality.

Low variations have thus been obtained where replicate tests have been carried out by one worker, but where a number of workers have carried out tests either in the same laboratory or in different laboratories, much higher variations have been observed.

Summary.

1. An attempt has been made to find the variability of the modified methylene blue test when carried out under research conditions and under routine conditions.
2. A series of 265 accredited milk samples tested in duplicate by one worker, showed no variation in samples reducing within 5 hours, but small variations were observed in the better quality milk. These variations increased in number and magnitude as the reduction time increased. The maximum variation observed was one hour, but the highest average variation for any group of samples was only 15 minutes.
3. Another series of 63 high grade milk samples were tested in quintuplicate by one worker who examined the tubes every 5 minutes. The mean of the maximum variations observed was only 9 minutes, and the mean coefficient of variations was under 1 per cent.
4. A series of 111 high grade samples examined by four separate workers during winter showed much higher variations, the mean of the maximum variations being 1 hour 23 minutes and the mean coefficient of variation 6.5 per cent.
5. A series of 153 low grade samples examined by the same

four workers during summer gave lower variations, the mean of the maximum variations being 46 minutes.

6. The variations observed during the course of the tests carried out by the four workers showed a gradual increase according to increasing reduction times.

7. It seems that the magnitude of the variation is influenced by:—

   (a) Intervals between examination.
   (b) Quality of the milk tested.
   (c) Number of workers.
   (d) The personal factor.

8. A comparison of the variability of the results of the modified test with those obtained by other investigations using the American standard method, shows that half hourly inversion of the tubes has improved the accuracy or reproduceability of the reduction times.

References.

FAY, A. C. (1930). *J. Agric. Res.*, 40, 855.
FRAYER, J. M. (1937). *Vermont Agric. Exp. Sta. Bull.* No. 424.
GRIMES, M., BARNETT and REILLY (1927). *Proc. Roy. Dublin. Soc.*, 18, 437.
MEMORANDUM (1937) *Min. of Hlth. London, Memo.*, 139/*Foods.*
PROVAN, A. L., ROWLANDS, A., EGDELL, J. W. and THOMAS, S. B. (1937). Unpub. data.
THORNTON, H. R. (1937) *J. Dairy Sc.*, 20, 693.
THORNTON, H. R. and HASTINGS, E. G. (1930) *J. Dairy Sc.*, 13, 221.
WILSON, G. S. et al. (1935) *Med. Res. Council Spec. Rep.* No. 206.

THE RESAZURIN TEST—A COMPARISON WITH THE MODIFIED METHYLENE BLUE TEST.

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Resazurin was first suggested as an indicator of the hygienic quality of milk by Pesch and Cimmert (1929). The dye when added to fresh milk is blue in colour, and as the bacterial flora increases in number and activity, the milk turns purple pink, vivid pink and finally white. The change from blue to pink is irreversible, but the reduction of the pink dye to the colourless form is reversible.

Methylene blue is reduced to its white form in milk at an Eh of approximately + 0.05 to + 0.07 volt, whereas, according to Ramsdell (1936), resazurin reduces to the pink modification at an Eh of about + 0.1 volt. Thus the reduction of resazurin to the purple pink and pink stages occurs at a higher oxygen level.

Comparison of resazurin reduction times and bacterial numbers was made by Waldbauer (1931), whilst Mundiger and Wolf (1933) compared the reduction of the dye with colony counts and Breed counts. They state that the results of the test did not give a very good correlation with the bacterial counts of the milk but they consider the test suitable for the rapid detection of poor quality milk. Demeter and Forg (1934) and Schwarz and Seeleman (1936) came to the same general conclusion as to the value of the resazurin test for milk grading. Ramsdell, Johnson and Evans (1935) worked on a series of 630 market milk samples which were tested by the resazurin and methylene blue tests, and found that the examination of the resazurin tubes after one hour of incubation at 37°C. was generally sufficient to detect most physiologically abnormal and pathological samples, as well as milk containing large numbers of actively growing organisms. They suggest that making two observations of the tubes, the first after one hour of incubation and the second after two hours, gives a more complete picture of the quality of the milk. These workers also compared the rate of reduction of resazurin by asceptically drawn udder milk and found that a high catalase content was invariably associated with considerable reduction of the indicator, whilst methylene blue was reduced within 8 hours in only two of the 49 udder samples tested. One sample containing 16 million leucocytes per millilitre did not reduce methylene blue within 8 hours, but showed considerable reduction of resazurin in one hour. They observed that in every udder sample showing reduction of resazurin within 2 hours there was a high leucocyte count of one million or more per ml., regardless of the bacterial content.

Moldavan (1936 and 1937) used the one hour incubation period as a means of grading milk into five classes and found that the results checked very well with the keeping quality of the milk tested by smell and taste after incubation for 16 hours at 70°F. He states that the simplicity, rapidity and dependability of the test make it a valuable method for the early detection and correction of faulty methods of milk production.

Ramsdell (1936) considers the test more suitable than the methylene blue test for the grading of milk and claims several advantages for the former—resazurin is more rapid, more sensitive to the reducing influences of abnormal milks and will detect the presence of slow reducing organisms such as the peptonizing group of bacteria. Also, with the short incubation period of one hour, the bacterial flora approximates more closely the initial flora than when longer incubation periods of 4 — 6 hours at 37°C. are used.

Jenkins (1937) used the test for the grading of pasteurised cream and his results give better correlation with plate counts than those obtained with methylene blue reduction. He attributes this closer correlation than that obtained by other workers using raw milk, to the inactivation of the leucocyte influence due to pasteurisation. Johns (1938) concludes that there is little difference between the resazurin and methylene blue tests in the time required for complete reduction, particularly with the better grades of milk. Barnett, Rutan and Keenan (1937) compared the test with methylene blue reduction, the standard plate count and Breed microscopic count. They suggest that the test can be very useful for the preliminary detection of abnormal or high count milk which can be further examined by microscopic methods. Used in this way it is a valuable adjunct to microscopic diagnosis in eliminating the time normally spent in diagnosis of good milk.

Frayer (1938) as the result of an extensive investigation states that the resazurin test correlates poorly with the methylene blue test and the standard plate count but shows a broad correlation with the cell count of milk drawn as asceptically as possible from individual cows.

He found that the indicator is sensitive to physiologically abnormal and pathological milk, to the presence and activity of bacteria, and is very sensitive to either strong sunlight or artificial light. He considers the test to be dependable, in that replicate tests yield similar results. It appears that initial cooling of the milk seems definitely to retard reduction. He suggests that supplementary microscopic examination is necessary if the one hour incubation period is employed and the results used as a basis for advisory work.

Technique of present work.

During the course of eight months (February—September), 575 samples of Accredited milk were tested in duplicate by means of the Methylene Blue and Resazurin tests. Both tests were carried out according to the modified method (Memorandum 1937), 10 ml. of milk being examined and inverted at half hourly intervals. One tenth ml. of 0.05 per cent. Resazurin (Eastman) solution was added to each 10 ml. of milk. Moldavan (1937) and Frayer (1938) have used one ml. of a 0.005 per cent. solution of the dye with success. They maintain that this lessens the likelihood of recrystallisation if the solution is held for any length of time at 50°F. or under. During the course of our work, the 0.05 per cent. solution was kept in the dark at room temperature and it was found that the solutions in daily use became contaminated ; colony counts on milk agar being over 5,000 per ml. at 37°C., and 16,000 at 25°C. Care was therefore taken to use fresh solutions and to check for sterility. Three control tubes were put up with each batch of samples tested :—(a) 10 ml. of mixed milk + 1 ml. of tap water : (b) 10 ml. of mixed milk + 1 ml. of methylene blue solution ; (c) 10 ml. of mixed milk + 1/10th ml. of resazurin solution. These tubes were immersed for 3 minutes in boiling water to destroy the natural reducing system present in the milk, but it was found that some change to purple pink occurred in the resazurin control. A better resazurin control was obtained by holding a tube of known good quality milk and resazurin in iced water. The tubes were incubated in the same water bath at 37° — 38°C., protected from any prolonged exposure to sunlight or artificial light.

A record was made of the time at which the resazurin tubes became purple pink, pink, and finally white. A similar procedure to that used in reading the reduction of methylene blue was used for the final reduction of resazurin, the tubes decolorised to within 5 mm. of the surface of the milk or to within 5 mm. of the bottom being taken as reduced, whilst tubes showing partial decolorisation were not inverted.

Results.

The complete reduction of resazurin to white correlates very closely with methylene blue reduction, the coefficient of correlation being as high as 0.87 (Table I). The reduction of resazurin was distinctly slower than methylene blue, taking, on the average, 35 minutes longer. Twenty-three per cent. of the samples were reduced at the same time by both tests, fifty-five per cent. gave longer resazurin reduction times and twenty-two per cent. longer methylene blue reduction.

The reduction of resazurin to purple pink also gave a fair statistical correlation with methylene blue reduction, the average reduction time being approximately half that of the reduction of the two indicators to their end points.

Table I.

A statistical comparison of methylene blue and resazurin reduction times for a series of 575 samples of raw accredited milk.

Indicator	*Mean Reduction time (Hours)*	*Standard deviation (Hours)*	*Correlation coefficients*	
			Variable	*r*
Reduction of Methylene blue	6.24	3.07	Reduction of methylene blue and reduction of resazurin to white.	+0.872
Reduction of resazurin to white	6.83	2.99	Reduction of methylene blue and reduction of resazurin to purple pink.	+0.658
Reduction of resarzuin to purple pink	3.23	2.31		

In applying the test to grade milk by means of one hour's incubation at 37°C., four colour grades have been suggested, namely, blue—good; purple pink—doubtful; pink—poor; and white—very poor. This classification correlates fairly well with methylene blue reduction (Table II). Of the 422 samples remaining blue after one hour's incubation with resazurin, 363 (86 per cent.) took

Table II.

Comparison of the colour of resazurin in one hour with methylene blue reduction time.

Colour of resazurin in 1 hour	*Methylene blue reduction time*				*Number of Samples*
	Over 9 hrs.	*7½-9 hrs.*	*5½-7 hrs.*	*5 hrs. and under*	
Blue	85	172	106	59	422
Purple blue	5	11	12	56	84
Pink	—	1	4	36	41
White	—	—	—	28	28
Total	90	184	122	179	575

5½ hours or over to reduce methylene blue. If the reduction to purple pink is taken as the arbitrary dividing line between satisfactory and unsatisfactory milk, it will be observed that quite a number of the samples (11 per cent.) that would be condemned, do not reduce methylene blue within 7 hours.

The quicker reduction of resazurin in such samples may of course be due to the presence of end of lactation milk or mastitis milk, and the presence of the latter could be checked by microscopic examination after one hour's incubation.

If the colour of resazurin after two hours' incubation is used for grading purposes, it is suggested that the dividing line for unsatisfactory milk should be taken at the stage where reduction to vivid pink occurs (Table III). This does not impose as strict a standard as methylene blue reduction in 5½ hours and a number of samples that take 7 hours or more to reduce the latter would still be considered unsatisfactory by this method. A summary of the results of grading by both indicators is given in Table IV.

It would appear from these results that the most satisfactory way of utilizing the resazurin test at present is to grade milk by it according to the stage of reduction brought about in one hour's incubation at 37°C. Milk supplies should be tested as soon as possible after arrival at a milk factory, and when samples are taken by public health or agricultural authorities for advisory purposes, the samples could be transported and held before examination according to the regulations prescribed by the Ministry of Health for official samples of designated milk.

Samples retaining the original blue colour for one hour can be considered satisfactory and advisory work concentrated on the milk supplies which show various shades of reduction within this time, commencing with the poorest class. If the staffing and equipment of the laboratory in question is adequate, it should be possible to carry out further tests particularly the plate count or direct microscopic examination as soon as the preliminary resazurin results are obtained. The plate counts would be carried out on the original sample which should be returned to the refrigerator as soon as the resazurin test is set up, or at any rate held in the coolest available place. The direct microscopic examination may be made on the milk from the partially reduced tubes—the one hour's incubation at 37° may encourage the growth of long chained streptococci, and will not affect the body cells to any appreciable extent. In order to obtain information regarding the approximate number of organisms due to utensil contamination and inefficient cooling of the milk, it should be advisable to carry out microscopic examination of the original sample strictly according to Breed's technique.

Table III.

Comparison of the colour of resazurin in two hours with methylene blue reduction time.

Colour of Resazurin in 2 hrs.	*Methylene blue reduction time*				*Number of Samples*
	Over 9 hrs.	*7½-9 hrs.*	*5½-7 hrs.*	*5 hrs. and under*	
Blue	80	142	74	28	324
Purple pink	4	35	29	24	92
Pink	6	7	18	72	103
White	—	—	1	55	56
Total	90	184	122	179	575

Table IV.

Unsatisfactory samples according to suggested resazurin grades classified according to methylene blue grading.

Reduction of Methylene blue	*Number of Samples*	%	*Reduction of Resazurin*					
			Purple pink in 1 hour		*Pink in 2 hours*		*White in 5 hours*	
			No.	%	*No.*	%	*No.*	%
(Unsatisfactory) Within 5 hours	179	31	120	21	127	22	145	25
(Satisfactory) Above 5 hours	396	69	33	6	32	6	10	2
Total	575	100	153	27	159	28	155	27

As an alternative method of grading, the tubes can be removed on reduction to purple pink and the times recorded. The comparative results given in Table V show that samples reduced to this colour in half an hour are of very poor quality and those reduced in one hour are unsatisfactory. Samples taking 1½ hours to 2½ hours before reduction can be considered of fair quality and those taking 3 hours or more definitely of good quality. All the tubes could be removed at the end of the 3 hours period, thus saving another 3—4 hours which would be required for methylene blue to attain a similar grade.

Table V.

Purple pink stage of resazurin reduction compared with mean methylene blue reduction times.

Reduction of Resazurin to purple pink (hours)	*Number of Samples*	*Mean reduction time of Methylene Blue (hours)*
0.5	72	1.9
1.0	78	4.1
1.5	50	5.2
2.0	53	6.3
2.5	49	6.7
3.0	40	7.2
3.5	15	7.1
4.0	41	7.8
4.5	34	7.7
5.0	12	8.0
5.5	26	7.9
6.0	36	7.9
6.5	19	7.7
7.0	18	8.9
7.5	10	10.3
8 hours or over	24	10.3

Discussion.

The extent of resazurin reduction within one hour at 37°C. can be used for the preliminary grading of milk for advisory purposes, but although the test under these conditions saves a good deal of time and labour as compared with methylene blue reduction, much further experience of the test with different types of market milk is required before it can replace the latter for official grading. Information with regard to the following practical points are particularly required :—

1. The type and concentration of dye to use and the methods of preparation and storage of stock solutions which will prevent bacterial contamination and recrystallisation.
2. The effect of cold storage of samples for periods of 12—14 hours on reduction as compared with the reduction times of the milk before holding at 32°—40°F.
3. The influence of sunlight and artificial light on reduction.
4. The correlation of the preliminary reductions at 37°C. with the keeping quality of milk at 60°F.
5. The influence of mastitis milk, colostrum, end of lactation milk and the action of leucocytes and other udder cells on the reduction of the dye.
6. The total and viable bacterial content of normal and abnormal samples (mastitis milk, etc.) at the time of reduction to purple pink, pink and white.

7. The extent of the variations observed in the readings of the different reduction stages by a number of workers carrying out the test under routine conditions.
8. The correlation of reduction at 30°C. with colony counts and coliform tests carried out at the same temperature as well as with direct microscopic count and keeping quality. Some preliminary work carried out by us shows interesting possibilities at this temperature. Incubation for 1½—2 hours will give results comparable with those obtained in one hour at 37°C.
9. Since incubation need only be carried out for one hour at 37°C. and at most for 3 hours at 30°C., it will be of interest to find out whether half hourly inversion has any influence on the reduction time.

Summary.

1. A comparison of the results of the examination of 575 samples of accredited raw milk by means of the resazurin test and the methylene blue test has been carried out, the tubes being examined and inverted at half hourly intervals in both tests.

2. It was found that the reduction of resazurin to the white stage correlates very well with methylene blue reduction, although the former was distinctly slower than the latter; an average difference of 35 minutes was observed.

3. The reduction of resazurin to purple pink also gave a fair statistical correlation with methylene blue reduction, but about 10 per cent. of the samples that reduced resazurin to this stage in one hour failed to reduce methylene blue within 7 hours. This may be due to the presence of abnormally secreted milk in these samples. It is known that methylene blue is not very sensitive to some types of such abnormal milk.

4. It is suggested that the test can be utilized for adivsory purposes, particularly when used in conjunction with microscopic examination. Samples which retain the original blue colour for one hour at 37°C. can be considered satisfactory, and further field and laboratory work concentrated on the milk supplies which show reduction within this time.

5. Reference is made to the type of further information required with regard to the practical application of the test to milk grading before it can be accepted as an alternative to the methylene blue test for official purposes.

References.

BARNETT, W. D., RUTAN, H. and KEENAN, J. A. (1937), *J. Dairy Sc.*, 20, 705.

DEMETER, K. J. and FORG, J. (1934) *Molk. Ztg.* (*Suddutsche.*) 32, 3.

FRAYER, J. M. (1938) *Vermont Agric. Exp. Sta. Bull.* No. 435.

JENKINS, H. (1937) *Vermont Dairy Operator's and Manager's Assoc.* 16, 47.

JOHNS, C. K. (1938) *Pers. Comm.*

KEENAN, J. A., BARNETT, W. D. and RUTAN, H. (1937) *J. Milk. Tech.*, October, 22.

MEMORANDUM (1937) Min. of Hlth., London, *Memo* 139/*Foods.*

MOLDAVAN, A.(1936) *Canadian Dairy and Ice Cream Journal*, July.

———— (1937) *Vermont Dairy Operator's and Manager's Assoc.* 16, 50.

MUNDINGER, E. and WOLF, E. (1933) *Milk Ztg.* (Hildesheim), 47, 171.

PESCH, K. L. and CIMMERT, V. (1929) *Milch. Forsch.* 8, 551.

RAMSDELL, G. A. (1936) *Vermont Dairy Operator's and Manager's Assoc.* November p. 3.

RAMSDELL, G. A., JOHNSON, W. T. and EVANS, F. R. (1935) *J. Dairy Sc.*, 18, 705.

SCHWARZ, G. and SEELEMAN, M. (1936) *Deut. Molk. Ztg.*, 57, 1417. (*Chem. Abstr.*, 31, 1108.)

WALDBAUER, OLGA (1931) *Kiserlet Koslem*, 34, 128. (*Chem. Abstr.*, 26, 2797).

FACTORS INFLUENCING THE QUALITY AND CHEMICAL COMPOSITION OF BUTTER.

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Although the change from farm to factory butter started later in Wales than in many other countries, it has been very marked since the operation of the Milk Marketing Scheme. In spite, however, of the increased competition from local factories and foreign supplies, considerable quantities of farm-house butter are still obtainable in certain districts. Among others, the Aberystwyth area receives its butter both from farm-house and factory, and in the present article it is proposed to consider some preliminary data regarding the quality and composition of the butter obtained from these two sources.

The factory butter on the market at Aberystwyth is mainly of New Zealand and Danish origin, but the proportion of butter from local factories is rapidly increasing. The farm-house butter is derived from farms ranging between sea level and an altitude exceeding 1,000 feet. Only in a small proportion of these farms are there butter makers who have been instructed in the work, the workers on most farms having had no special training.

The samples of butter used for this investigation were obtained through normal channels of supply. The factory butters were purchased at shops in Aberystwyth and the farm samples obtained either from the local market, or direct from the farms.

On arrival at the laboratory these were judged and marks allocated for quality according to the following scale :—

	Maximum Score
Flavour and Aroma	50
Texture	25
Freedom from moisture	15
Colour	10
TOTAL	100

If we grade the 187 samples which were examined according to the number of marks received for quality, we find that the percentage falling into each division is as follows :—

Table I.

Showing Percentage of Farm and Factory Samples falling into different grades.

Grade	*1st.*	*2nd.*	*3rd.*	*4th.*
Minimum marks for grade	85	80	75	—
% of Farm Samples in grade	18.2	41.0	21.3	19.5
% of Factory Samples in grade	35.4	41.5	15.8	7.3

The above table indicates that a greater proportion of the butter from both the farm and the factory falls into the second grade (with score range of 84-80) than into any other. The proportion of factory samples reaching the first grade is practically double that of the farm samples, and owing to lack of uniformity a relatively high number of the latter samples were distributed in the third and fourth grades.

In considering the scores awarded to the farm butter from different sources, a marked difference is found between the butter made by trained butter makers, and that obtained from other farms where no special instruction had been received. This is evident from the following table where the farm butter samples made by trained workers have been graded separately and compared with the samples from the remaining farms.

Table II.

Showing difference in grade between Farm Butter produced by Trained and Untrained Workers.

Grade	*1st.*	*2nd.*	*3rd.*	*4th.*
Untrained Workers	12.3	32.9	28.8	26.0
Trained Workers	67.7	29.0	3.3	—
Best Factory Butter	53.0	47.0	—	—

The above comparison shows clearly the remarkable improvement which the training of the workers effects in the quality of farm-house butter. This improvement is such that the farm butter compares favourably in grade with the best factory butter on the market. It is true that the best factory butter shows greater uniformity in that no samples fall into the third grade. On the other hand, owing to the more satisfactory flavour of the carefully produced farm butter a higher proportion of this butter reached the first grade in spite of the fact that the factory butter received more credit for freedom from moisture.

Keeping Quality.

In order to compare the relative keeping qualities of the butters, portions of each sample were stored at 15—16°C. and also at 0—4°C. The average figures obtained for keeping quality at these two temperatures are shown in the following table :—

Table III.

Average Keeping Quality of Variously Produced Butters.

	15—16°C.	*0—4°C.*
Farm Butter (Untrained Workers)	12.5 days.	18.8 days.
do. (Trained Workers)	12.7 ,,	18.6 ,,
Factory Butter (Unpasteurised Cream)	7.6 ,,	13.7 ,,
Factory Butter (Pasteurised Cream)......	19.8 ,,	24.8 ,,

The farm samples having a consistently high initial quality did not possess the keeping qualities that might have been expected from such high grade butter, and the above figures show that the training of the worker had no influence in prolonging the period over which the butter maintained a satisfactory flavour. Further, the data obtained for the factory butter suggest that a good keeping quality is unattainable unless the cream is pasteurised. Thus, while the factory butter made without pasteurisation of the cream only kept for an average of 7.6 days, that manufactured from efficiently pasteurised cream remained in good condition for 19.8 days. It is of interest to note in this connection that Guthrie and his co-workers (1) observe that pasteurisation of cream is beneficial to the keeping quality of butter, not so much because it kills the harmful bacteria, which in certain of their creams were only present in small numbers, but because the harmful milk enzymes are destroyed.

Moisture Content of Butter.

The water content of butter is of special importance seeing that it represents the largest non-fatty constituent. In the following table the amount of water present in butter on the English market as determined by Richmond (2) is compared with the water content of butter samples marketed at Aberystwyth.

TABLE IV.

Description of Samples	*No. of samples examined*	*Moisture Content*			
		Below 10%	*11—14%*	*14—16%*	*Above 16%*
English (Richmond)	143	13.9	70.7	14.7	.7
Foreign (Richmond)	417	1.8	88.2	9.0	1.0
Welsh Farm	101	15.8	60.4	23.8	—
Factory (Welsh Foreign)	59	—	29.6	62.1	8.3

The figures obtained for the English samples by Richmond agree closely with the results for the Welsh farm samples. It should be pointed out that the English and foreign samples were taken by Richmond about 25 years ago, and it is evident that there is a pronounced difference between the foreign samples of that time and the factory samples of to-day. While 25 years ago only 9% of the foreign samples had a moisture content between 14—16%, most of the present factory samples show a moisture between these limits.

The figures also show that a higher percentage of the present factory butter exceeds the 16% limit than was the case 25 years ago. These tendencies towards a higher level in the moisture undoubtedly reflect the efforts that are being made to produce a butter which is as close to the legal standard as possible.

One portion of the water in butter consists of minute microscopic droplets ranging in diameter from less than one micron (1/25,000 inch) to 15 microns (3/5,000 inch) (3). These microscopic droplets are carried into and locked up within the butter granules during the churning process. They are evenly distributed and firmly held in the butter. The remaining portion of the water is held between the granules, adhering to the surface of the butter grains. This is less finely divided, less evenly distributed and more loosely held than the microscopic grains.

The results of this investigation show that the farm butters contained a larger quantity of this second type of moisture than did factory butters. It is this second type which becomes apparent on examination of the fractured edge of a block of butter and which exudes on pressure being applied to the block. The score awarded for freedom from moisture was lowered in proportion to the amount of this apparent moisture. The total moisture estimations carried out on the butter samples show that there is no relation between this and the loosely held water on which the freedom from moisture score depends. The following figures give the average scores awarded to the two types of butter together with the average moisture determined by chemical analysis.

	Average Score (Max. 15)	*Average Moisture %*
Farm Samples	11.6	11.40
Factory Samples	13.3	15.04

It is evident from these figures that while the factory samples contained less apparent moisture and were consequently accorded a higher score than the farm samples, the actual moisture content of the factory butter exceeded that of the farmhouse by a wide margin.

The Chloride Content.

The amount of salt added to butter is governed largely by local preference, which varies from one locality to another. Thus the high salt content which is especially demanded in the rural districts of Wales is regarded elsewhere as objectionable. This more heavily salted butter is in particular demand in the mining and quarrying districts of North Wales where butter containing little salt is regarded as insipid and flavourless. In this investigation, the maximum salt content for Welsh butter was 7.02 per cent., and the minimum, 0.97 per cent. The analytical results for the salt content of butter from the various sources that were examined are set out below :—

TABLE V.

The Salt content of butter from different sources.

Source	*No. of samples*	*Maximum*	*Minimum*	*Mean.*
Welsh Farm	88	6.85	.97	2.27
Welsh Factories	39	7.02	1.12	3.26
Foreign Factories	43	2.45	.51	1.39

The Protein Content.

Although present in comparatively small amounts, the protein is a very important constituent of butter. It controls to a large extent the texture of the butter. Van Slyke and Hart (4) say that if the proteins are thoroughly washed from butter, the " mottles " which are usually caused by over-ripening the cream (5) cannot be produced, no matter how unevenly the salt is distributed. Complete removal of the buttermilk by washing is one of the essential conditions. in preventing " mottled " butter. In the following table the values for the protein content of the samples from different sources have been subjected to statistical treatment (6).

TABLE VI.

Protein content of Butter from Farm and Factory.

Source.	*Number of Sources*	*Degrees of Freedom*	*Mean Protein Content*	*Sum of Squares.*
Farm	8	7	.453	.0325
Factory	4	3	.534	.0147
Pooled variance (V) → .00472			t → 1.92	

The average protein content of the butter from all sources amounted to .475, and the above value for it shows that the difference between the protein of the farm and factory produce is not significant. The protein in butter is closely related to the moisture and as the moisture may exist in the granules and between the granules, so also does the protein of the butter exist in these two distinct water media. Washing and working butter will remove almost all of the intra-granular protein, but will not reduce that which is contained within the grains. It is the intra-granular protein that has the most harmful effect and is mainly responsible for the fact that butter containing an excessive amount of butter milk is of poor keeping quality. It seems that the protein contained inside the granules has no such marked effect on the keeping quality. It follows that a butter having a higher total protein than another is not of necessity inferior in keeping quality provided that it is free from excess intra-granular protein. In this investigation, examples were obtained of butter samples having a protein content of 0.600% possessing slightly better keeping qualities than samples only containing 0.400% protein.

Acidity of Butter.

The free acid present in butter can be divided into two classes depending on its source. About half the acidity is due to butter milk and about half to free fatty acids (7). The serum acid of the butter is soluble in water and consists chiefly of lactic acid, while titration in alcohol gives a measure of the total free acids. Fig. 1 indicates how the acidity determined after extraction with water and that obtained after extraction with alcohol vary with age.

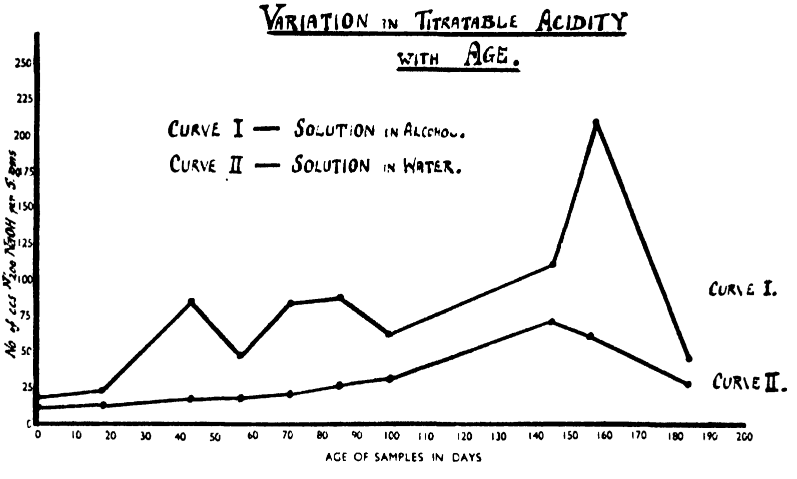

FIG. 1.

The above figure shows that there is a steady increase up to a certain time in both the water soluble acids and the total acids of the butter. This seems to point to a liberation of water soluble acids such as butyric acid during hydrolysis. It is also evident from the above that a maximum level of free acids is ultimately reached, followed by a decline due to the decomposition of these acids.

The next table shows the amount of water soluble acid in relation to the keeping quality of the butter :—

TABLE VII.

Relationship between the Acidity of Water Suspensions and the keeping quality of Butter.

Range of Acidity (cc. $\frac{N}{200}$ acid per 5 gm.)	*Actual Acidity (cc. $\frac{N}{200}$ acid per 5 gm.)*	*Average Keeping Quality in Days c. 15—16°C.*	*Average Keeping Tuality in Days c. 0—4°C.*
0— 5	3.24	17.8	20.3
5— 8	6.65	15.3	22.9
8—10	8.67	14.7	20.5
10—12	10.85	12.2	18.6
12—15	13.62	13.3	21.5
15—20	16.91	13.8	22.8
20—30	22.60	11.5	21.2
Over 30	40.88	3.5	7.5

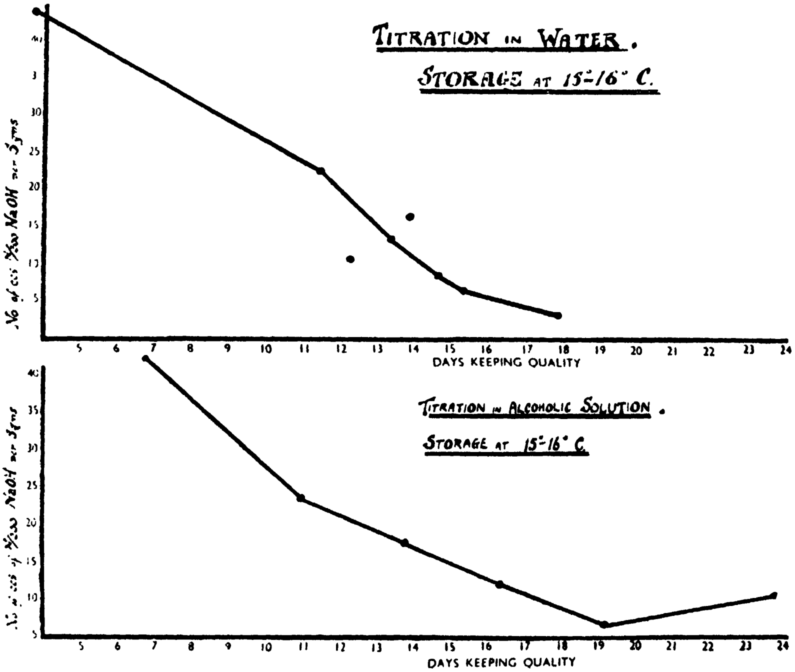

FIG. 2.

The correlation coefficient of -0.94 given by the above data shows that an exceptionally close relationship exists between the keeping quality and the initial acidity of the water suspensions. A close relationship was also found to exist between the keeping quality and the total free acid as determined in alcohol ; a correlation coefficient of -0.87 being obtained. Fig. 2 shows the relation between the keeping quality and the acidity of the water and alcohol suspensions.

Seasonal Variation in the Composition and Quality of Butter.

The data obtained in this investigation have been arranged into two groups, the Danish and Welsh samples being included in one, and the New Zealand samples in the other. In figure 3, the variations which occur in the average score for quality is shown. A steady improvement is seen to occur in the Danish and Welsh samples throughout the spring and early summer, to a maximum in August. A decline subsequently sets in, and a lower grade of butter is produced throughout the winter months. In the case of the New Zealand samples the curve is more erratic, but there is a steady decline in the quality from mid-March throughout the earlier summer rising to a maximum in September. A second peak occurs in March.

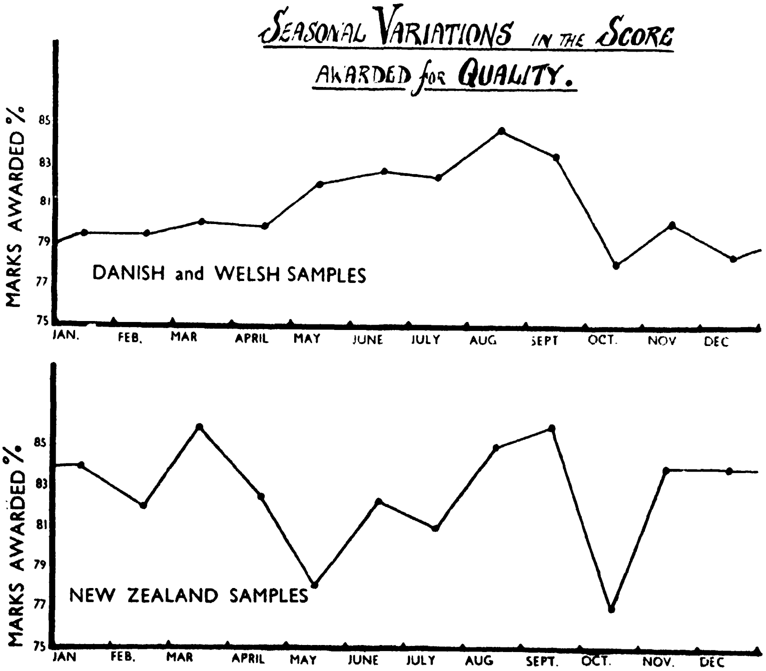

FIG. 3.

Fig. 4 shows the average Reichert-Meissl numbers found for each month. The curve for the Welsh and Danish samples shows that there is a fairly regular seasonal change in the amount of soluble volatile fatty acids. There is a maximum quantity present in June samples and a steady decrease until a maximum occurs in mid-November.

This reflects the decrease in the amount of soluble volatile fatty acids which occurs throughout a normal lactation, freshly calved cows giving fat far richer in these acids than stale cows (8). There is a fairly steady increase in the Reichert-Meissl number from November to June corresponding with the increase in proportion of newly-calved cows.

The New Zealand samples give two fairly definite peak periods which shows that the introduction of freshly-calved cows to the milking herds is not confined to one season of the year, to the same extent as it is in Danish and Welsh herds. The samples which gave the highest Reichert-Meissl numbers were those purchased in January and April, and minimum values were obtained in February and December samples.

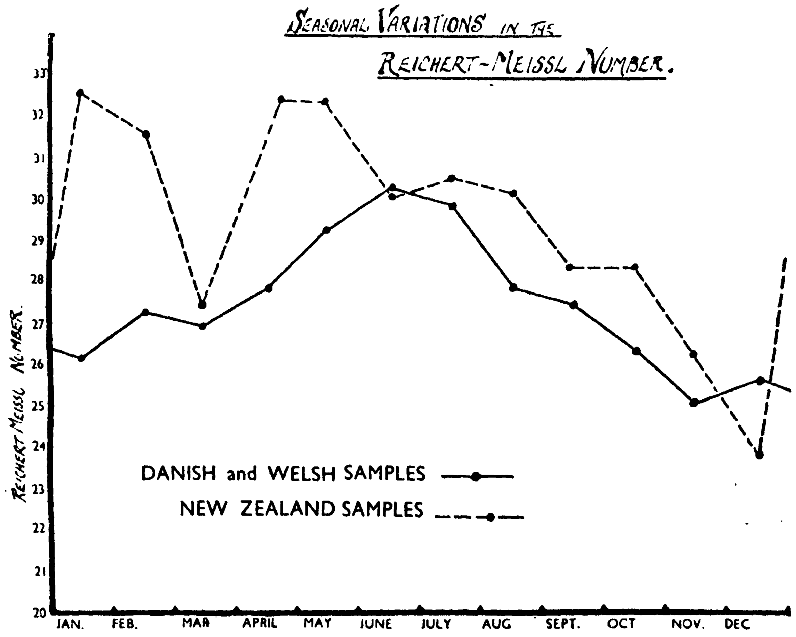

FIG. 4.

It is evident from the curves in figure 5, that there is a definite seasonal change in the content of unsaturated fatty acids as revealed by the iodine absorption number. Coulter and Combs (9) have shown that there is a seasonal change in the iodine value of butter fat corresponding to the amount of fresh grass which the cows are receiving as food. These workers found maximum iodine values to occur in June and July. In these Welsh and Danish samples, the maximum value was obtained in the latter month. This is probably due to the fact that the " flush " period is late on many of the upland Welsh farms where some of these samples were obtained. The average iodine values for the months of October, November, December and January were uniform, after which a steady increase set in, culminating in a maximum in July samples. There seems to be two maximum periods for iodine values in the New Zealand samples, the one occurring in July, the other in mid-November, while minimum values are given by samples purchased in April and September.

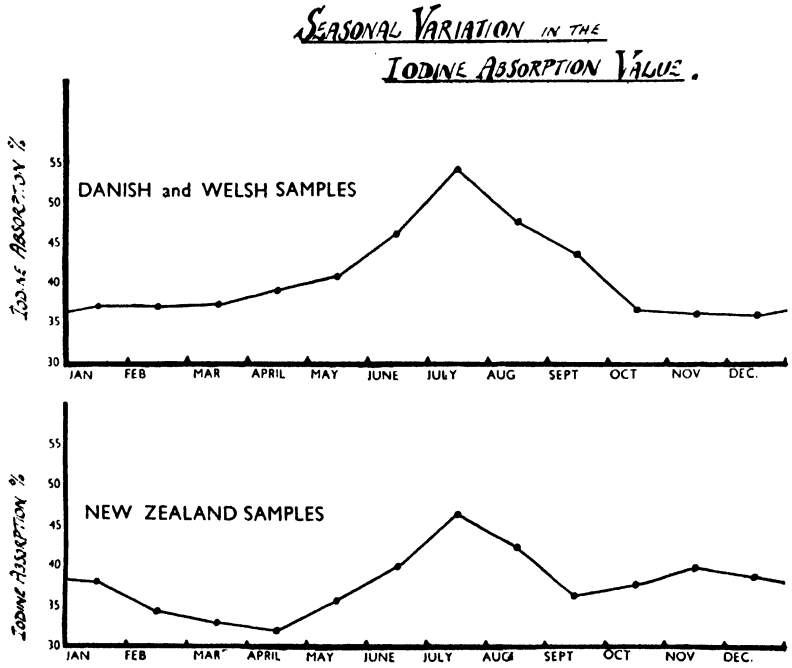

FIG. 5.

The carotene of butter is of special interest in view of the close correlation that exists between the carotene and vitamin A content of the butter (10). Fig. 6 shows the monthly averages of carotene concentrations for the two groups into which the butter samples were divided. The graph reveals that New Zealand butter contains, on an average, much more carotene than the Welsh and Danish samples. The richest New Zealand butter judged on carotene content is marketed in this country from November to February, while the poorer samples are sold during June and July. The rise in the curve for the Danish and Welsh butter during May and June shows the important influence of summer grazing on the carotene content of these samples.

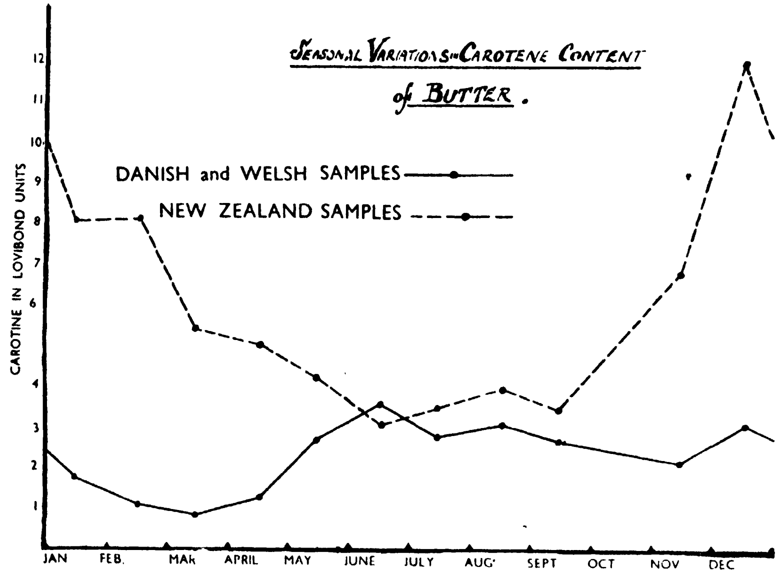

FIG. 6.

Summary and Conclusions.

Samples of farm-house and factory butter marketed in Wales have been examined for quality and chemical composition. Greater uniformity was found in the factory samples than in the farm samples, mainly due to the marked difference that exists between the butter made by trained butter makers at the farm, and that obtained from farms where no special instruction had been received. The farm butter produced by trained workers compared favourably in initial quality with the best factory butter, but it did not possess such good keeping quality due to the absence of cream pasteurisation.

Present day factory butter has a higher moisture content than that produced in the past. Estimations of moisture in butter show that there is no relation between it and the apparent moisture which exudes on the application of pressure and on which the score for freedom from moisture depends. While factory samples contained less apparent moisture and were consequently awarded a higher score than the farm samples, the actual moisture content of the factory butter exceeded that of the farm house by a wide margin.

Considerable fluctuations were obtained in the chloride and protein content of the butter samples examined, the highest concentration of the former reaching 7% and reflecting the demand for highly salted butter that exists in certain Welsh areas. With regard to the protein content of the samples, a butter having a higher protein content than another was not found of necessity to be inferior in keeping quality provided that it showed freedom from excess of intra-granular protein.

During the storage of these butter samples there was a steady increase up to a certain time in both the water soluble and total acids. A maximum level of acidity was ultimately reached followed by a decline. An exceptionally close correlationship existed between the keeping quality and the initial acidity.

Seasonal variations in the composition and quality of the butter marketed in Wales are indicated, and important differences in these variations are found to exist between butter produced in the Northern and that produced in the Southern Hemisphere. The Reichert-Meissl number showed a definite seasonal change for the Welsh samples, the maximum corresponding to the period of the year when most of the freshly-calved cows entered the milking herds. The carotene content of New Zealand butter proved to be on the average higher than that of Welsh butter. Summer grazing had a marked effect in raising the concentration of unsaturated fatty acids and of carotene in Welsh and Danish butter.

Acknowledgments.

The writers desire to thank Professor T. W. Fagan for the helpful interest he has taken in the work, and Mrs. R. O. Davies for assistance in connection with the judging of the butter samples.

References.

1. GUTHRIE ET ALIAS. *J. Dairy Science* 1936. p. 267.
2. McKAY, G. L. and LARSEN, C. *Principles and Practice of Buttermaking,* p. 312.
3. HUNZIKER, O. F. *The Butter Industry.,* p. 458.
4. McKAY, G. L. and LARSEN, C. *Principles and Practice of Buttermaking,* p. 280.
5. MINISTRY OF AGRICULTURE AND FISHERIES, *Bulletin* No. 57, p. 12.
6. FISHER, R. A. *Statistical Methods for Research Workers,* Oliver and Boyd.
7. BOUSKA, F. W. Acidity of butter and its by-products. *J. Dairy Science,* 1923, p. 122.
8. BARTHELL, Trans. GOODWIN. *Milk and Dairy Products.* p. 161.
9. COULTER and COMBS. *J. Dairy Science.* 1934. p. 552.
10. WATSON, S. J., DRUMMOND, J. C. *Empire J. Exp. Agri. Vol.* 1, 1933. p. 68. et alais.

FIELD TRIALS WITH PEDIGREE (STATION-BRED) AND INDIGENOUS STRAINS OF GRASSES —DATA COLLECTED 1938.

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Six series of trials laid down in various Welsh counties are discussed in this paper; small plots sown in 1928 (E.86), in 1929 (E.97) and in 1936 (E.224) : quarter-acre plots sown in 1934 (E.229) and the larger demonstration areas, plots of from one to four acres, sown in 1931 (E.140) and in 1933 (E.228).

The trials were laid down on fields of different farms with a view to gaining information on the behaviour of Station-bred and/or indigenous strains in simple mixtures sown under ordinary farm conditions, and at the same time to demonstrate the value of such mixtures. The older trials sown in 1928, 1929 and 1931 have demonstrated the persistency of the Station-bred and indigenous strains when compared with ordinary commercial types.

Data on the behaviour in the earlier harvest years of the trials sown in 1928, 1929 and in 1931 have already been reported upon by Thomas (1, 2, 3); the present report covers field evidence collected in the year 1938 only.

Material and Methods.

The seeds were put down under a cereal nurse and in general a hay crop was taken during the first two or three years; at some centres hay was harvested every year, rarely were the seeds continually grazed. Manuring practices varied widely: in the main the previous crop of roots received a dressing of dung with or without slag; the nurse and seeds usually received a dressing of slag, sometimes nitro-chalk, and dung was then applied every two or three years to the grass. Top dressings of lime or slag have been given to fields of the older trials, and in this connection the farmers have increased their annual purchases as a result of the recent Government policy.

The centres were visited during the summer and autumn of 1938; where possible samples of hay or aftermath were taken from both the trials and a similar sized adjacent area of the farmer's mixture, and later analysed by the percentage productivity method (4). Elsewhere the swards were analysed by the percentage area method, by counts of tillers per unit area, and sometimes by a general estimation (by eye) of the contribution of the various species in terms of percentage area. At some centres only generalized notes were made. The farmers concerned were consulted in regard to their opinion of the behaviour of the mixtures.

The 1928 Trials (E.86).

In the spring of 1928 a one-tenth acre strip was sown along with the farmer's mixture at several centres in a number of the counties, and in 1938 (tenth harvest year) twenty centres were examined in the counties of Brecon, Cardigan, Carmarthen, Merioneth, Montgomery and Pembroke.

The Mixtures.

Particulars of the mixtures used are given in Table I.

The Mixtures.

Table I. Details of plot mixtures, sown 1928.

Species and strain.	*Mixtures in lb. per acre.* I.	II.	III.
Italian rye-grass.	6	6	6
Perennial rye-grass (indigenous)	14	—	14
Cocksfoot (Station-bred)	—	16	—
Rough-stalked meadow grass	4	4	4
Crested dogstail	4	4	—
Montgomery late-flowering red clover	4	4	4
English wild white clover	3	3	3

Mixtures I and III, containing perennial rye-grass, were designed for the better soil types, while Mixture II, containing cocksfoot, was sown on less fertile soils.

The farmer's mixture, as a rule, contained broad red clover, and perhaps late-flowering clover, with Dutch white rather than wild white (3).

The figures in Table II (tenth harvest year, 1938) emphasize the superiority of the herbage on the plots, and this is largely owing to the persistency of the indigenous perennial rye-grass and Station-bred cocksfoot. The ingress of Yorkshire fog, bent, sweet vernal, and weeds was very marked in the farmers' swards.

At three centres sown with Mixtures I or III, the position of the strips was no longer apparent : this was associated with little manuring in recent years. At the three remaining centres there were only slight differences between the strips and the farmers' mixture, but confirming the main body of results.

Results.

TABLE II.

The average percentage contribution of sown grasses, Yorkshire fog, bent, wild white clover and other species and area of bare ground in the tenth harvest year*.

Mixtures.	*Sown grasses.*	*Yorkshire fog and bent.*	*Wild white clover.*	*Other species***	*Bare ground.*
Plots***	45	20	21	12	2
Farmer's ***	21	43	12	21	3
Plots****	53	7	7	33	—
Farmers'****	32	17	13	38	—

*Data from fourteen centres.

**Other species included sweet vernal, fine-leaved fescue and miscellaneous weeds.

***Percentage area.

****Percentage productivity.

In fields which have been continuously put up for hay indigenous perennial rye-grass and Station-bred cocksfoot have given less opportunity for wild white clover to flourish than in the farmer's mixture. The wild white clover in the farmers' mixture was usually unsown.

The 1929 Trials (E.97).

These trials comprised two one-tenth acre plots sown at each centre in the spring of 1929, and in the same counties. In 1938 seventeen of the existing centres were visited, and where possible botanically analysed.

The Mixtures.

Particulars of the mixtures used are given in Table III.

TABLE III.

Details of the plot mixtures sown in 1929.

Species and strain.	*Mixtures in lb. per acre.*			
	Ia.	*Ib.*	*IIa.*	*IIb.*
Italian rye-grass	6	6	6	6
Perennial rye-grass (indigenous)	—	—	9	9
Cocksfoot (Station-bred	16	—	9	—
Cocksfoot (Danish)	—	16	—	9
Rough-stalked meadow grass	4	4	4	4
Crested dogstail	4	4	—	—
Montgomery late-flowering red clover	4	4	4	4
English wild white clover	3	3	3	3

The mixtures were designed to compare Station-bred with Danish cocksfoot in simple mixtures; Mixture I for uplands and Mixture II, containing indigenous perennial rye-grass, for somewhat better conditions.

Results.

TABLE IV.

Showing (a) the botanical composition (percentage productivity) of the plots and the farmer's mixture; (b) counts of cocksfoot tillers per 2½ sq. ft. in the ninth harvest year (1938)*

Mixtures.	*Perennial rye-grass.*	*Cocks-foot.*	*Rough-stalked meadow grass and dogstail.*	*Fog and bent.*	*Wild white clover.*	*Other spp.***	*Cocksfoot tillers per 2½ sq. ft.*	
								***
Ia.	4	34	6	38	9	9	32	13
Ib.	5	20	6	39	15	15	4	42
Farmer's.	4	20	7	37	11	21	—	—
IIa.	4	66	5	13	4	8	159	—
IIb.	22	7	12	33	13	13	63	—
Farmer's.	20	11	8	45	10	6	15	—

* Data cover eleven centres.
** Other species include sweet vernal, fine-leaved fescue and miscellaneous weeds.
*** One centre only.

The data in Table IV for the ninth harvest year again emphasize the persistency of the Station-bred cocksfoot. At two centres the position of the plots could not be identified; three centres were not analysed, but their general appearance confirms the data in Table IV.

The adverse effect of the Station-bred cocksfoot upon the yield of indigenous perennial rye-grass and wild white clover was very marked. The rye-grass was similarly affected at one centre which was grazed, but it was associated with the largest proportion of wild white clover. The practice of hard late spring grazing, and also of late hay cuts, favours the Station-bred cocksfoot and has a decided depressing effect on indigenous perennial rye-grass. The late hay cuts also hinder the development of the wild white clover.

At one centre under continuous hay, tiller counts of the commercial cocksfoot were greater than the Station-bred cocksfoot.

The 1931 Trials (E.140).

Large demonstration areas of one to four acres were put down in each of the Welsh counties in 1931. The areas were sown with Station-bred seed in simple mixtures with a strip, one-fourth acre, of commercial seed only through the centre of the Station-bred block. The seed rates of the two areas were identical. Twenty-eight centres were inspected in the seventh harvest year (1938) and at eighteen of these the swards were botanically analysed.

The Mixtures.

Particulars of the mixtures used for the Station-bred areas are given in Table V.

TABLE V.

Details of the plot mixtures, sown 1931.

Species and strain.	*Mixtures in lb. per acre.*			
	I.	*II.*	*III.*	*IV.*
Italian rye-grass.	4	4	4	4
Perennial rye-grass (indigenous)	—	8	—	—
Cocksfoot (Station-bred)	16	10	10	6
Timothy (Station-bred)	4	4	10	12
Red fescue (Station-bred)	—	4	—	6
Crested dogstail	4	—	4	—
Montgomery late-flowering red clover	4	4	4	4
Wild white clover	2	2	2	2
Alsike	—	—	—	4

In the quarter-acre strip of commercial seed, the ordinary commercial strains of the grasses were used throughout and at most centres Dutch white instead of wild white clover.

Results.

TABLE VI.

The botanical composition of the swards in the seventh harvest year (1938)*.

Mixture.	*Perennial rye-grass.*	*Cocks-foot.*	*Tim-othy.*	*Fine leaved fescue.*	*Rough-stalked meadow grass** and dogstail.*	*Fog and bent.*	*Wild white clover.*	*Other spp****
I ****	1	20	2	—	3	27	4	43
Com. ****	2	7	1	—	7	31	4	48
II ****	6	6	2	49	10	7	8	12
Com. ****	10	12	3	28	13	13	9	12
II, III, IV *****	11	20	T	22	6	13	19	9
Com. *****	5	7	T	13	8	33	16	18

*Data cover eighteen centres.
**Rough-stalked meadow grass not sown.
***Other species included sweet vernal and miscellaneous weeds.
****Percentage productivity (hay).
*****Percentage area.

The botanical analysis of the centres is summarized in Table VI; although the figures show considerable differences between the Station-bred and commercial swards, there were a few centres (four out of a total of twenty-eight), where the former at the time of visit in 1938 did not show to advantage over the latter. However, the farmers at these centres stated that the Station-bred herbage was earlier than the commercial in the spring, and that it remained more winter green.

Of the remaining six centres the Station-bred swards at five of them were better than the commercial, while at the sixth, sown with Mixture II, Station-bred perennial rye-grass and red fescue were more productive than the commercial types, but there appeared to be more cocksfoot on the commercial plot.

Perennial rye-grass, rough-stalked meadow grass and wild white clover each made appreciable unsown appearance at some of the centres. Station-bred red fescue in the mixture appears to have competed with the indigenous perennial rye-grass and Station-bred cocksfoot to an extent that placed them in an adverse position in relation to their commercial counterparts.

Chewing's fescue has been less aggressive on the whole, and has certainly not swarded nearly so well as the Station-bred strain : this is somewhat contrary to the evidence obtained for the same trial in its fifth harvest year (1936) (3). Station-bred red fescue has proved the more palatable, particularly during the winter and early spring, because of its greater degree of winter greenness. The sum effect has been that the Station-bred areas have therefore been grazed much harder during the early spring, and this has correspondingly depressed the indigenous perennial rye-grass and Station-bred cocksfoot. The commercial plots were usually less severely grazed, largely because of the relatively unpalatable nature of the Chewing's fescue. The more lenient grazing has been to the advantage of the commercial strips, and the indications are that rye-grass and cocksfoot have suffered less on the commercial than on the Station-bred areas.

The 1933 Trials (E.228).

These trials were laid down in a similar manner to those of 1931, and were confined to centres in North Wales. The experimental area at each centre varied from two to three acres, and included a one-quarter acre strip of commercial seed as well as the main block of Station-bred mixture. The seed rates of the two mixtures were identical. Owing to adverse weather conditions prevailing during the autumn of 1938, a botanical analysis of the centres was not carried out ; detailed field notes, however, were made at the ten centres visited.

The Mixtures.

Particulars of the mixtures used are given in Table VII.

In the commercial mixtures ordinary rye-grass, cocksfoot, timothy and Chewing's fescue were used ; a mixture of Cotswold late-flowering and broad red clover replaced Montgomery red clover.

TABLE VII.

Details of plot mixtures sown in 1933.

Species and strain.	Mixtures in lb. per acre.			
	I.	II.	III.	IV.
Italian rye-grass (Station-bred)	4	4	6	4
Perennial rye-grass (Station-bred)	14	8	—	—
Cocksfoot (Station-bred)	6	10	14	8
Timothy (Station-bred)	6	6	8	12
Red fescue (Station-bred)	—	—	4	6
Rough-stalked meadow grass	1	—	—	—
Crested dogstail	—	2	—	—
Montgomery late-flowering red clover	3	4	4	—
Wild white clover	1	1	1	1
Alsike	—	—	—	4

Wild white clover was used in all mixtures (including the commercial mixture). Mixture I was designed for good conditions ; Mixture II for second-class soils, Mixture III for upland (*ffridd*) areas and Mixture IV for peat land.

Results.

In the fifth harvest year (1938) the general appearance of the mixtures at the centres visited was as follows.

Mixture I. The commercial strip was clearly defined as the Danish cocksfoot had failed to persist as well as the Station-bred strain. Hay had been taken every year, and the Station-bred cocksfoot had dominated the sward competing with the Station-bred perennial rye-grass. Unsown Yorkshire fog, bent and rough-stalked meadow grass were a feature of the commercial areas.

The common practice of late hard spring grazing, putting up for hay late and cutting late, has favoured the cocksfoot. In this respect it is altogether probable that Station-bred cocksfoot will have been more favoured relatively than the commercial strain, particularly when the excessively active growth of the Station-bred in the aftermath period is given consideration.

Mixture II. Under hay conditions the swards produced in fifth harvest year (1938) were similar to those of Mixture I. Under conditions where the field was closely grazed as pasture, perennial rye-grass tended to dominate regardless of the original seeding. Where somewhat undergrazed, cocksfoot, with Yorkshire fog and bent, was prominent in the commercial strip, while Station-bred cocksfoot was prominent in the Station-bred area and with relative freedom from bent and fog.

Mixture III. Where this mixture has been sown in upland fields and grazed from the outset, the Station-bred cocksfoot and red fescue have persisted decidedly better than have their commercial counterparts. What remained of the latter, when seen in the autumn, was severely winter-burned in contrast to the light green of the Station-bred cocksfoot and dark luscious green of the Station-bred red fescue. Where the taking of hay has been practised the aggressiveness of the Station-bred cocksfoot was again evident, and there is a suggestion that it has competed with the Station-bred red fescue.

Mixture IV. Only one of the centres sown with this mixture was visited, and this was on part of a large field ; the area in question had been closed for hay every year, and stock had neglected the Station-bred sward, showing preference for the farmer's mixture, and for the commercial strip. The behaviour of the different species under contrasting systems of management will be dealt with in the general discussion.

The 1934 Trials (E.229).

These were single demonstration plots of Station-bred seed at a number of centres in Anglesey, Caernarvon and Denbigh. At one centre the plot was two acres, elsewhere the size was quarter of an acre. The plots were put own alongside the farmer's mixture.

Field notes were taken in the autumn of 1938 (fourth harvest year) at four of the five centres. The fifth centre was not visited, although an opportunity was found to discuss this trial with the farmer concerned.

The Mixture.

Only one seeds mixture was employed, and this was designed for tests under conditions of average to good soils. The mixture used is shown in Table VIII.

TABLE VIII.

Details of mixtures sown in 1934.

Species and strain.	*lb. per acre.*
Italian rye-grass	4
Perennial rye-grass (Station-bred)	15
Cocksfoot (Station-bred)	6
Timothy (Station-bred)	6
Rough-stalked meadow grass	1
Montgomery late-flowering red clover	5
Wild white clover	1

Results.

Fourth Harvest Year (1938). All the centres had been put up for hay in the first harvest year. One, which had been grazed since then was an excellent perennial rye-grass—wild white clover sward containing appreciably more rye-grass than the adjacent farmer's mixture. In the others, which had been closed for hay in 1938, Station-bred cocksfoot was prominent in the aftermath, together with Station-bred perennial rye-grass and rough-stalked meadow grass on the good soils, but with Yorkshire fog and bent on the poorer soils. Because of the excessively rapid growth of the Station-bred cocksfoot during the humid months of August and September, 1938, the plots were outstandingly productive during this period when compared with the farmer's mixture sown on the same field. Further reference will be made to this point in the general discussion later in this article.

The 1936 Trials (E.224).

In the spring of 1936 two plots (either one-tenth acre, or one-fifth of an acre, in size) were sown at each of fifty centres in the seven counties of Brecon, Cardigan, Carmarthen, Flint, Merioneth, Montgomery and Radnor. Station-bred perennial rye-grass and Station-bred cocksfoot were compared with the commercial types in simple mixtures under normal farm conditions. One plot therefore contained Station-bred seed of perennial rye-grass and/or cocksfoot and the other commercial seed.

Forty-two of these centres were visited in 1938, and an analysis made of the herbage on the plots at twenty-four centres.

The Mixtures.

Particulars of the mixtures used are given in Table IX.

TABLE IX.

Details of plot mixtures sown in 1936.

Species and strain.	*Mixtures in lb. per acre.*		
	I.	*II.*	*III.*
Italian rye-grass (Station-bred)	3	4	6
Perennial rye-grass (Station-bred)	24	16	6
Cocksfoot (Station-bred)	—	6	15
Rough-stalked meadow grass	1	1	—
Crested dogstail	—	1	1
Montgomery red clover	3½	4	4
English wild white clover	1	1	1

Station-bred Italian rye-grass was also used in the otherwise "all-commercial" mixtures. Mixture I was designed for good lowland soils: Mixture II for average conditions, and Mixture III for thin upland soils.

TABLE X.

Showing (a) the percentage botanical composition of the plots and (b) counts of tillers of cocksfoot and plants of red clover per 2½ sq. ft. in the second harvest year*.

Mixtures.	*Sown grasses.*	*Red clover*	*Wild white clover.*	*Fog and bent.*	*Other spp.* **	*Moss and bare ground.*	*Counts per 2½ sq. ft.*	
							Cocksfoot tillers.	*Red clover plants.*
I. Station-bred***	53	9	11	3	6	18	No data	No data.
I. Commercial ***	43	12	11	12	4	18	No data	No data.
II, III Station-bred ***	59	2	10	3	10	16	107	11
II, III Commercial ***	40	3	12	10	16	19	45	16
II Station-bred ****	46	40	3	3	8	—	100*****	17*****
II Commercial ****	36	42	2	7	13	—	122	9

* Data from twenty-four centres.
** Other species included miscellaneous weeds.
*** Percentage area method.
**** Percentage productivity method.
***** One centre only.

The figures in Table X show that in the second harvest year there was a pronounced difference between the Station-bred and commercial plots. The aggressiveness and high-tillering ability of the Station-bred cocksfoot has not been favourable to the red clover which has therefore been more abundant in the commercial plots. This is well illustrated in Table XI, giving average results from three centres only.

TABLE IX.

The average counts of tillers of perennial rye-rass and cocksfoot and plants of red clover per 2½ sq ft.*

Mixtures.	*Perennial rye-grass.*	*Cocksfoot.*	*Red clover.*
II. Station-bred	123	137	7
II. Commercial	127	59	13
Farmer's	105	36	8

*Data from three centres.

From the data it would appear that the Station-bred cocksfoot had competed adversely with the Station-bred perennial rye-grass.

At two of the centres sown with Mixture II, commercial cocksfoot gave better results than the Station-bred. Counts of cocksfoot tillers per 2½ sq. ft. made at one of these centres are included in Table X. At nine other centres which were not botanically analysed there was no marked distinction between the plots, although there was a tendency for the Station-bred plots to be more leafy than the commercial.

Detailed notes from the remaining centres all indicated the greater tillering capacity and the more leafy herbage of the Station-bred swards when compared with commercial. A few farmers had sown Station-bred seeds in their own mixtures, and in such cases the commercial plot was readily distinguished, while the herbage of the Station-bred plot, and the farmer's mixture, was very similar in general appearance.

Discussion of Results.

Persistency of the indigenous and Station-bred types. The evidence accumulated from the trials detailed above shows the value of including indigenous and Station-bred types in seeds mixtures. In a few cases in the older trials the Station-bred plots did not show to advantage over the commercial plot and/or farmer's mixture at time of visit. The farmers concerned, however, have pointed out that the Station-bred swards were superior to the commercial swards in the past, and at some centres the Station-bred herbage proved more winter green than the commercial (season 1937-38).

Where Station-bred cocksfoot has been sown without rye-grass or Station-bred red fescue, differential grazing has taken place favouring the Station-bred cocksfoot relative to the commercial type. This occurs because the Station-bred cocksfoot comes away quickly in the aftermath, and if it is not immediately grazed it becomes coarser and less palatable than the commercial, and therefore when the stock are turned in late in the back-end they graze the commercial bare before touching the Station-bred. On the other hand indigenous perennial rye-grass without cocksfoot or red fescue has been severely grazed because of its superior palatability.

Where Station-bred types of these two or three species have been included in the same mixture, intercompetition has taken place, usually favouring the less palatable species.

The superior results obtained by the Station-bred strains over the commercial strains in the second harvest year (1936 trials) has been readily apparent. The leafiness and tillering ability of the station-bred types are of great value, even for short duration leys; their aggressive character, however, did adversely affect the red clover.

Points raised by farmers relative to leafy and ordinary strains. With regard to the older trials (1928, 1929) the farmers were unanimous in their appreciation of the Station-bred plots, particularly of their behaviour in the later harvest years. In the case of the more recent trials (1933-1936) two criticisms were made: these related to the poor palatability of the Station-bred cocksfoot and Station-bred red fescue, and to the difficulty experienced in curing the leafy hay on the Station-bred plots. There can be no doubt, of course, that a young leafy hay is more difficult to dry as hay than a more stemmy crop. Whether the problem is to be overcome by a change in methods of harvesting, or by placing reliance upon the more stemmy strains for special-purpose hay mixtures is outside the scope of this paper to discuss.

With regard to differential palatability—the other point raised by farmers—this difference between strains within the one species appears to be widened when small plots of the Station-bred strains are sown across a field where ordinary seed has been used. Palatability within a relatively highly palatable species like rye-grass or cocksfoot is not fundamentally of great importance, but it has to be said that during the first and second harvest years the leafy strains are on the whole slightly less palatable, relatively, than their stemmy counterparts. The real comparison is very difficult after the first harvest year, because by then the stemmy (and non-persistent) strains are dying out, and the whole sward complex has changed. We are then not dealing with the relative palatability of two strains within the same species, but with two entirely different sward complexes, which may in fact show very wide differences in palatability.

Palatableness is again influenced tremendously by stage of growth, and it is here that the matter is of immediate practical importance. It is in the aftermath phase, and in the late summer generally, that the chief criticism of unpalability is brought against the Station-bred plots containing leafy cocksfoot. This criticism is, therefore, largely consequent upon the fact that leafy cocksfoot (more so even than leafy strains in the other species) grows away very rapidly, and especially after hay has been cut on the field. The commercial strains grow away more slowly at this period, so that when the stock are turned in, say a month after the hay is cleared, the leafy strains are already in an advanced stage of leafy growth.

The whole evidence means that in practice the leafy strains are ready to be grazed in the aftermath much earlier than the ordinary strains. If they are required specifically to be left over to a later period in the autumn, and to cater for late September and October grazing, the leafy strains can be grazed during the first month or so after taking hay, and will, if then rested, provide abundance of late autumn feed.

Inter-species and inter-strain competition. The foregoing data suggest that the after-management of a sown pasture exerts an important influence upon the botanical composition of its herbage. The inclusion in the seeds mixture of Station-bred and other leafy strains of grasses and clovers is, however, a point of some importance, for this provides a sound and proper basis for maintaining over a long term of years a pasture ever rich in the sown species. The ordinary stemmy and non-persistent strains are unable to maintain themselves longer than the first two or three years other than on some very rich soils and under certain exceptional systems of management.

When complex many-species mixtures are used, and especially where these are based upon leafy strains, the botanical composition of the resulting pasture will, after some years, bear a close relationship to the type of management that will have been superimposed upon it. All the evidence brought forward goes to suggest that the more simple (in terms of species) the seeds mixture the more easily can the resultant pasture be controlled in practice. The inclusion of too many species, each having its own reaction to different schemes of pasture management, means that with every change in management (or mismanagement) one species or set of species will gain the ascendancy over the others. This may act detrimentally upon the pasture as a whole. An example of such is brought out in the present data where leafy perennial rye-grass and leafy cocksfoot have been sown in the one seeds mixture and where the cocksfoot has dominated under systems of management not conducive to the proper maintenance of rye-grass.

Looked at from the point of view of the subsequent maintenance of the sward, malpractices are bound to occur under normal farm conditions in Wales, where hard grazing in the spring is to a large extent unavoidable on sheep farms. Hard spring grazing, however, will always react to the detriment of such plants as rye-grass and cocksfoot, while having a less serious influence upon say red fescue. If these three species (using the leafy and persistent strains) are included in the one seeds mixture, and the field on which they are sown is subjected to severe grazing by sheep every winter and spring, the vigorous red fescue gains ascendancy and may dominate the sward.

The data reviewed above show that timothy when sown in a mixture with rye-grass and cocksfoot is not able to establish and maintain itself properly in the sward at least where the growth is not carefully under control from the outset. These and other data collected by the Station therefore lend support to the view that seeds mixtures should be of the simplest kind, and this is particularly true in relation to mixtures containing leafy strains. Where a very careful control of the herbage is possible, then more species can be added to the mixture, but under normal farm conditions the simpler the seeds mixture the better.

On good soils leafy perennial rye-grass and wild white clover can form the basis of the mixture, while on poorer land leafy cocksfoot will be substituted for leafy rye-grass. Normally the only additions necessary will be a proportion of Italian rye-grass and ordinary commercial perennial rye-grass to cover the early periods of sward establishment, while where hay is to be taken in the first and second year, the addition of Montgomery and other strains of red clover may be necessary. It may ultimately be found, however, that it is better to rely on special-purpose mixtures designed specifically for hay production. The indications are that such hay mixtures would best be based upon timothy and Montgomery red clover. The simple special-purpose mixture designed either for grazing or for hay is always likely to be more successful, cheaper in cost, and easier to manage under ordinary farm conditions than a complex general-purpose mixture.

Summary.

(1) Field trials with indigenous, Station-bred and commercial strains have been described.

(2) Evidence has been obtained to illustrate the persistency and high tillering ability of the indigenous and Station-bred strains.

(3) The results have been discussed with particular attention to the reaction of the farmers to the trials and the inter-species, inter-strain competition which has taken place.

Acknowledgments.

The authors' thanks are abundantly due to Professor Sir R. George Stapledon, C.B.E., M.A., for facilities to carry out the investigations, and his active interest in the work. The co-operation of the County Agricultural Organizers concerned, and of the farmers on whose land the trials were laid down is gratefully appreciated.

References.

1. THOMAS, M. T. Simple seeds mixtures containing pedigree and indigenous strains compared with ordinary commercial mixtures for permanent grass. *Welsh J. Agric.* VII. pp. 182-6.
2. ——————— (1935) Field trials with pedigree and indigenous strains of grasses. *Ibid.* Vol. XI. pp. 147-57.
3. ——————— (1937) Field trials with pedigree and indigenous strains of grasses. *Ibid.* Vol. XIII. pp. 160-171.
4. DAVIES, WILLIAM (1931) Methods of pasture analyses and fodder sampling. *Welsh Plant Breeding Station Report.* No. 1.

BIOLOGICAL STUDIES IN THE CONTROL OF DOCKS (*RUMEX* SPP.)

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Rumex obtusifolious, L. (=Broadleaved Dock) and *Rumex crispus*, L. (=Curled Dock) are injurious weeds the destruction of which may be required by a notice issued by a County Agricultural Committee as authorised by the Minister of Agriculture under the Corn Production Acts—Repeal 1921.

As many County Authorities are, of late years, exercising their authority in this direction with zeal and efficiency, considerable interest has been awakened in the agricultural community in the biology of these plants and in the efficacy of methods of their eradication.

There follow the results of some investigations carried out in the Department of Agricultural Botany, University College of North Wales, Bangor, during the Sessions 1936-8.

Materials and Methods.

Plants grown from seed in a greenhouse and adult plants collected from Anglesey and Caernarvon were used in the case of *Rumex obtusifolius* and *Rumex crispus*, together with *Rumex acetosella* (=Sheep's Sorrel) in some of the investigations. During the inert winter season, when growth could not be maintained under field conditions, cultural work was carried on in a greenhouse maintained throughout at a temperature of 60°F under thermostatic control.

Seedling Morphology.

A short account of some significant aspects of the seedling morphology of the three species is included to show their mode of development up to the adult stage under standard greenhouse conditions above defined.

Germination in all cases is epigeal, the cotyledons in *Rumex obtusifolius* and *Rumex crispus* being lanceolate, with an obtuse apex, while in *Rumex acetosella* it is obovate with an obtuse tip.

Table I gives the time in days from sowing to the appearance of the rough leaves.

The time interval between the successive appearance of each leaf varies within the plant and from plant to plant, as is seen from

TABLE I.

Species	*Appearance of hypocotyl above soil*	*Cotyledons fully expanded*	*Rough Leaves*											
			1*st*	2*nd*	3*rd*	4*th*	5*th*	6*th*	7*th*	8*th*	9*th*	10*th*	11*th*	
1*	14	25	35	47	63	73	85	95	102	109	116	(Irregular from 9th)		
2*	14	25	35	41	53	66	78	89	97	106	116	126	135	(Irreg. from 11th)
3*	15	25	35	42	54	64	73	82	92	(Irregular from 5th to 6th)				

1* = *R. obtusifolius*, 2* = *R. crispus*, 3* = *R. acetosella*.

the table. For a time each new leaf emerges from the axil of the last formed leaf, up to the 9th in *R. obtusifolius*, the 11th in *R. crispus*, and from the 5th to the 6th in *R. acetosella*. Subsequently, new leaves emerge irregularly and variously from the axils of the older leaves.

In the foliage of *Rumex obtusifolius* there is a gradation in shape from the first leaf, broadly ovate to the cordate base and slightly more elliptical shape of the adult leaf. Leaf venation, at first only lightly marked, in each succeeding leaf becomes more strongly pronounced—the seventh leaf showing the first indication of wavy edges, and the pattern becomes stable about the ninth.

In *Rumex crispus* the first leaves are typically ovate, becoming progressively more lanceolate as the adult stage is reached. The typical crisped edges of the adult *R. crispus* leaf is first indicated in the sixth leaf, and venation becomes more strongly defined in the same sequence. The stable adult form is attained in the eighth leaf of the series.

In *Rumex acetosella* the first two leaves are obovate, the third and the fourth becoming more ovate in shape. The fourth leaf shows the first indication of a basal lobe, and this becomes more developed on either side in succeeding leaves. In the seventh leaf the lobes are elongated and pointed, but the eighth arrives at the mature adult stage exhibiting the small pointed auricles between the lobes and the remainder of the lamina. The shape of the leaves that appear irregularly in the axils of earlier formed leaves after the fifth and sixth leaf stages vary very widely.

The three species exhibit a gradation in shape and form of leaf through a juvenile period. Arrival at a stable persistent pattern of foliage indicates the establishment of the adult plant in each case.

As seen above, the various species differ in the time required for firm and complete establishment whether judged by the interval it takes from germination to complete the progression through foliage patterns into the stable and persistent adult form, or by the point of interruption of the emergence of juvenile leaves from the axil of the last formed leaf (the ninth in *Rumex obtusifolius*, the eleventh in *Rumex crispus*, and the fifth or sixth in *Rumex acetosella*.)

Judged by these criteria establishment is complete in *Rumex obtusifolius* in sixteen weeks, in *Rumex crispus* in fifteen, and in *Rumex acetosella* in eleven weeks.

Since plants are more vulnerable and thus more readily eradicated in the juvenile stage than as established adults, effective control is best accomplished within the above defined periods of pre-establishment.

Stem Anatomy.

The vascular tissue is made up of a ring of collateral bundles, capped at each end by a group of collenchymatous fibres. In the *Rumex crispus* stem the vessels are more numerous per xylem group than in *Rumex obtusifolius*. In the pith of the former there is, in addition to a ring of anomalous phloem groups, some with no xylem, others with two to three xylem vessels situated on the outside, i.e., in the reverse position to what is the case in a collateral bundle.

In old stems of *Rumex obtusifolius* the secondary xylem occurs as a continuous band, while in *Rumex crispus* it is found in wedges separated by narrow rays of parenchyma full of starch. In both species alike calcium oxalate crystals occur in some of the cells of cortex and pith, whereas none occur in the roots of plants of either species.

Development of Root System.

In *Rumex obtusifolius* and *Rumex crispus* the root system remains as a single tap root for about fourteen weeks. Subsequently in *R. obtusifolius* some of the secondary roots thicken, giving the root system a fanged appearance. The root of *R. crispus* retains its single tap root feature for a much longer period. In both, root contraction pulls the crown of the plant to soil level by the fifth leaf stage, further contraction withdrawing the crown below the soil surface.

In *Rumex acetosella* the root system remains fibrous for all time. Root buds are first formed when the plant is about seventeen weeks old. By the sixth leaf stage the crown of the plant is withdrawn to soil level, and further contraction pulls it below.

Up to the appearance of secondary thickening the roots of *Rumex crispus* and *Rumex obtusifolius* are very similar in structure, *Rumex crispus* showing a few more vessels in each xylem group.

In old roots of *Rumex obtusifolius* secondary lignified xylem occurs in patches, between which occurs storage parenchyma filled with starch. In the cortex lignified stone cells occur singly and in groups—the cells of the cortex being densely filled with starch grains.

Old roots of *Rumex crispus* have the secondary lignified xylem disposed in a ring of wedges, separated by storage medullary rays filled with starch. Here the parenchymatous pith, as well as the cortex, is densely filled with starch, and the cortex accommodates lignified hypodermal groups as well as stone cells.

Vegetative Reproduction in Rumex species.

It is often quoted in literature dealing with weeds that Docks reproduce by root buds. Trials were conducted with fractions of dock plants (*Rumex obtusifolius* and *Rumex crispus*) to ascertain the relative powers of regeneration of portions derived from various regions in the parent adult plant. Trial pieces, as under, were planted in pots in the greenhouse, observations being extended throughout the year.

All the vegetative stem portions gave rise to shoots. In the adult plant it is hard to determine the true limits of the hypocotyl, for having contracted it occupies but a very small length, and each portion termed " hypocotyl region" above, included within the 2.5 cm. of tissue, a portion of vegetative stem at its upper end and a portion of root at its lower. The shoots in each case arise from the stem portion, and roots when they arise do so from the base of the new shoot.

TABLE II.

Description	*Approx. length (cms.)*	*Approx. diameter (cms.)*	*Number of pieces*	*Result*
Vegetative stem	2.5	1.5—2.0	10 of each spp.	All appearing in 7 days.
Hypocotyl region	2.5	1.5	10 of each spp.	All appearing in 7 days.
Root pieces from hypocotyl downwards	2.5	0.5—1.5	10 of each spp.	No regeneration.

Periodic inspection of the root portions showed that they remained completely inert. No development or quickening towards regeneration occurred, and all the pieces rotted within a month.

Another series of root portions, equal in number but of twice the length for each piece (5 cm.), were subsequently set up under similar conditions, with duplicates on moist blotting paper covered by glass jars. Within three months the entire number in the former lot perished, and of those on blotting paper five pieces (three *Rumex obtusifolius* and two *Rumex crispus*) only survived. A thin layer of callus formed over the distal cut end of these. Each gave rise to a root, but in none were any buds formed. After four months all these root portions had rotted away.

In a further attempt at obtaining regeneration from roots, twelve whole roots of each of the two species, from which the vegetative stems had been severed before planting, were planted in boxes of soil in the greenhouse at as near as possible their normal depth. After an interval of seven months only three of the largest roots of *Rumex obtusifolius* and one of *Rumex crispus* remained quick; rotting, proceeding downwards from the severed top end, accounted for the rest. After a further period of three months the remainder rotted away.

Further trials were set to determine the extent of the regenerative tissue and the mode of regeneration in the two species, plants with unfanged tap roots being chosen for the greater ease of manipulation.

Ten plants of each of the two species were completely debudded and planted. A duplicate set of plants were kept for a week in humid warm atmosphere to induce latent buds to quicken into activity and thus offer a better chance of complete removal of lateral buds.

In no case were any further buds formed, all the plants

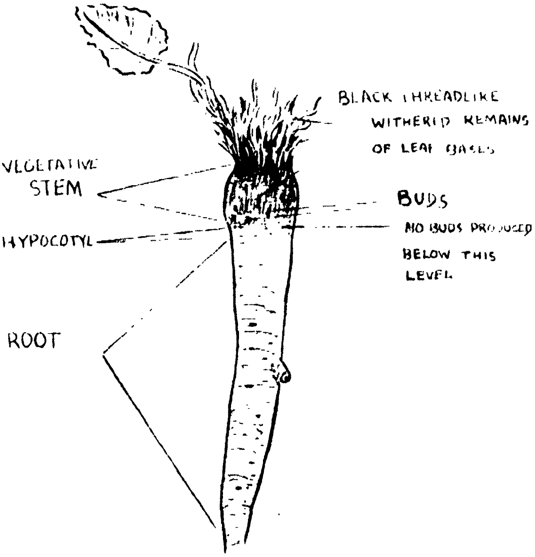
BLACK THREADLIKE WITHERED REMAINS OF LEAF BASES
VEGETATIVE STEM
BUDS
HYPOCOTYL
NO BUDS PRODUCED BELOW THIS LEVEL
ROOT

FIG. 1. Diagram of *Rumex obtusifolius*, showing extent of bud production.

eventually rotting, and potential regeneration is confined to buds already formed.

TABLE III.

Description	*Length (cm.)*	*Diameter (cm.)*	*Number of pieces*	*Results*
Top 1 mm. below lowest limit of bud production.	1.0	1.0	10 of each species	No regeneration.
Top 5 mm. below lowest limit of bud production.	1.0	1.0	10 of each species.	No regeneration.
Top 2 mm. *above* lowest limit of bud production.	1.0	1.0	10 of each species	Regeneration from buds already formed in 7 days. In no case were buds produced from the cut surface, even after an interval of several weeks.

It is evident that where all potential bud bearing tissue has been removed from the hypocotyl region no regeneration is possible in *Rumex crispus* and *Rumex obtusifolius*, but if only a 2 mm thickness of regenerative tissue remains bearing buds regeneration occurs readily. Where only a very small portion of vegetative stem (regenerative tissue) remains attached to a root, provided it bears a bud, regeneration is there also possible.

If spudding, where practised, be not exercised at a sufficient depth to sever all potential bud bearing tissue, leaving but a meagre portion of the vegetative stem intact, to an uncritical observer it may seem that regeneration has occurred from root tissue. Such conceivably is the false warrant behind this much quoted belief in the existence of root buds in Docks. These trials definitely disprove the existence of root buds in *Rumex crispus* and *Rumex obtusifolius*.

Eradication of *R. obtusifolius* and *R. crispus* by Spudding.

"Spudding" was carried out on plants which had been transplanted on to a plot of ground behind the Agricultural Buildings, Bangor, as well as on undisturbed plants growing in their natural surroundings (12 plants to each treatment in each of the two situations were used).

Spudding was done at three depths, one inch, 1½—2 inches, and at least four inches.

Spudding at a depth of 1 inch has the effect only of temporarily checking the plant, as illustrated by the fact that after 10 days all the plants, both *R. obtusifolius* and *R. crispus*, in both situations are throwing up shoots (see Table IV.)

This treatment only removes a small portion of the apex of the vegetative stem, but by so doing the plant is stimulated to throw up more shoots from lateral buds.

Spudding at a depth of 1½—2 inches is more drastic and injurious to the plant, some of them even failing to recover, and even those that do succeed take from 18 to 37 days to restart growth. The table shows that *Rumex crispus*, being smaller in size, is checked more than is *Rumex obtusifolius*.

A comparison of the two situations also shows that undisturbed plants in the field are checked more and take longer to recover than do the transplants, possibly because the latter have been planted at a greater depth than the former, spudding in their case removing a smaller portion of the vegetative stem.

Examination of the plants revealed that, in those that failed to recover, all the vegetative stem portion had been removed, the root alone remaining. In the others, a portion of the vegetative stem, bearing buds, remained; the amount of vegetative stem bearing buds remaining on the root determined the time taken for recovery —the greater the amount the quicker the recovery.

Spudding at 4 inches deep completely removed all the vegetative stems from all the plants, with the exception of one very large transplant of *R. obtusifolius*, bearing an elongated vegetative stem, complete removal of which was not possible, due to its being at a greater depth than 4 inches. The elongated stem was evidence of its having been planted below its normal depth.

All the decapitated roots were left in the soil until completely rotted. This is further evidence that root regeneration in *Rumex obtusifolius*, and *Rumex crispus* does not occur.

Eradication of *R. obtusifolius* and *R. crispus* by Defoliation.

It is generally known that continual defoliation will eventually exhaust the root system of any plant. It was therefore decided to test the efficiency and the practicability of this treatment as a means of eradication in the case of *Rumex obtusifolius* and *Rumex crispus*.

In order to ascertain the maximum interval that could be allowed to pass between each defoliation, a series of entire adult plants of *Rumex obtusifolius* and *Rumex crispus* were planted in pots of soil in the greenhouse. These were allowed to flourish undisturbed until it was considered that they had become acclimatised to greenhouse conditions.

Each plant was then lifted; the roots were washed clean of soil (great care being taken to prevent the rupturing of the absorbing

TABLE IV.

Depth of Spudding	*Rumex obtusifolius*				*Rumex crispus*			
	In the plots	*Time for recovery*	*In the field*	*Time for recovery*	*In the plots*	*Time for recovery*	*In the field*	*Time for recovery*
1 inch	All starting growth after 10 days.							
1½—2 inches	3 failed		4 failed		3 failed		6 failed	
	4 ,,	18 days	3 ,,	20 days	3 ,,	20 days	2 ,,	23 days
	3 ,,	21 ,,	2 ,,	22 ,,	2 ,,	24 ,,	2 ,,	25 ,,
	1 ,,	25 ,,	1 ,,	23 ,,	4 ,,	27 ,,	1 ,,	30 ,,
	1 ,,	37 ,,	2 ,,	25 ,,			1 ,,	36 ,,
4 inches	11 failed		All failed		All failed		All failed	
	1 ,,	40 days						

TABLE V.

Data for Rumex obtusifolius (weights in gramms).

Plant index	*1st day*	*No. of shoots*	*5th day*	*No. of shoots*	*10th day*	*No. of shoots*	*15th day*	*No. of shoots*	*20th day*	*No. of shoots*	*25th day*	*No. of shoots*	*30th day*	*No. of shoots*	*35th day*	*No. of shoots*
A	65.2	—	65.0	—	67.7	2	66.4	12	64.5	11	64.1	11	66.3	11	67.4	11
B	58.5	—	58.1	—	59.6	8	58.6	13	61.5	11	67.7	11	70.7	11	76.1	10
C	41.0	—	40.8	—	41.3	3	40.2	4	39.9	3	41.1	3	42.9	3	46.6	3
D	48.5	—	48.4	—	50.5	5	49.9	6	51.2	6	53.5	6	57.0	6	61.7	6
E	31.9	—	31.3	—	32.3	2	31.4	2	30.4	2	30.4	2	31.7	2	31.4	2
F	23.5	—	22.9	—	23.6	0	24.0	1	23.5	3	23.8	3	24.8	3	25.6	3
G	23.6	—	22.9	—	23.5	1	23.6	4	23.8	5	24.3	4	26.1	4	28.7	4
H	19.4	—	18.9	—	19.1	4	18.8	4	18.1	4	18.6	4	19.1	4	19.1	4

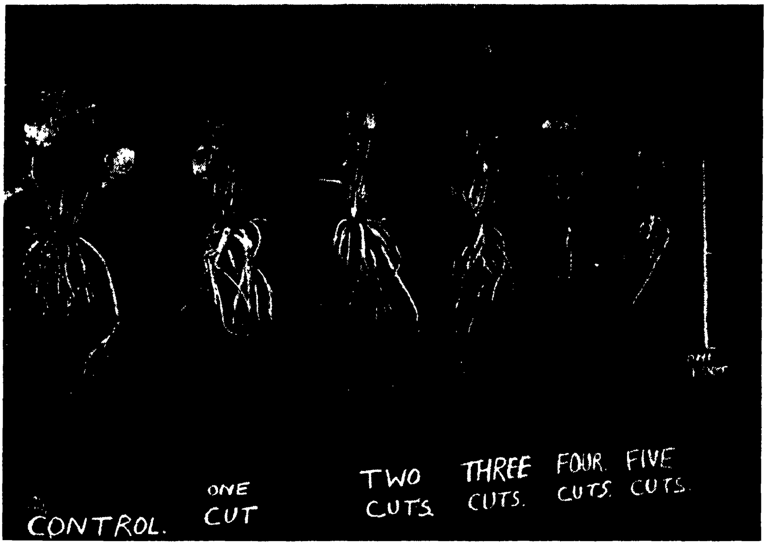

FIG. 2.—*Rumex obtusifolius*, showing effect of different intensities of defoliation.

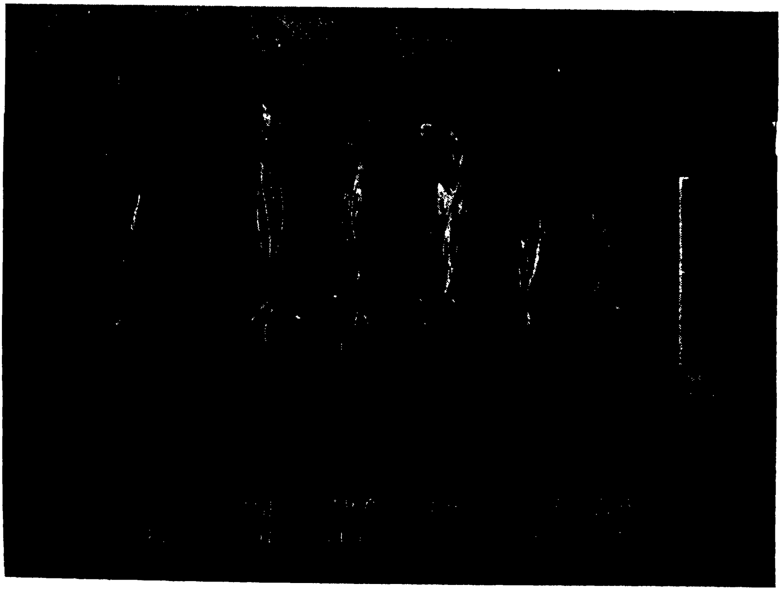

FIG. 3.—*Rumex crispus*, showing effect of different intensities of defoliation.

rootlets), and the surplus water absorbed with blotting paper. They were then defoliated, weighed, and then replanted. Each plant was weighed at intervals of 5 days after the roots had been carefully washed and dried, and a record kept of the weights, together with the number of shoots above soil.

All the plants lose a small amount in weight during the first 5 days, when the buds are activating. There is still a slight loss of weight up to the 20th day, during which the shoots are drawing more on the reserves in the roots and probably making only a small return of synthesised material. After the 25th day there is a gradual increase in weight, after which date also the number of shoots do not increase (Table V).

Thus, it takes approximately 25 days after defoliation for Dock plants of these species to start gaining in weight under these conditions. Obviously then, defoliation at 3 weekly intervals will prevent it gaining in weight, and if defoliation is repeated every 3 weeks the plant will eventually be exhausted.

Accordingly, a trial was conducted in the greenhouse on plants of both species grown from seed under controlled greenhouse conditions. The plants were 8 months old at the beginning of the trial. Defoliation was carried out at 3 weekly intervals, beginning at the end of June 1937 and continuing to the beginning of October.

They were lifted 3 weeks after the last defoliation, and the roots were carefully washed and dried with blotting paper. The plants were weighed, and the total number of shoots noted

TABLE VI.

Intensity of cutting	*Rumex obtusifolius*				*Rumex crispus*			
	Row A		*Row B*		*Row A*		*Row B*	
	Wt (gms)	*No of shoots*	*Wt (gms)*	*No of shoots*	*Wt (gms)*	*No of shoots*	*Wt (gms)*	*No of shoots*
Control	295 0	8	209 0	3	232 0	1	230 0	1
Once cut	218 0	6	162 0	4	155 0	1	107 0	1
Two cuts	194 0	6	193 0	4	72 0	1	62 0	5
Three cuts	137 0	11	102 0	8	88 0	6	80 0	2
Four cuts	64 0	5	56 0	3	53 0	4	34 0	1
Five cuts	71 0	6	55 0	3	30 0	1	27 0	1

Figures 2 and 3 illustrate the decrease in size of the roots with an increased intensity of defoliation.

In both species there is a marked and gradual fall in weight from the control plant to those subjected to defoliation 5 times (Table VI). Maximum shoot production occurs in those plants subjected to only 3 defoliations.

It was thought that this was due to inhibition in the first case, since it is a well known fact that the terminal bud on a branch inhibits the growth of secondary buds. Thus up to and including the second defoliation the leaves are inhibiting the production of new shoots, but after the third defoliation the inhibiting factor is removed, resulting in a sharp increase in the number of shoots. Further defoliation results in decreased shoot production, it being suggested that this is economy on the part of the plant.

It is commonly believed in rural areas that the more often Docks are defoliated the more vigorous is their subsequent growth. This may be due to abandonment of defoliation after the third time, enabling the plants to send up an increased number of shoots, thus increasing their synthesising capacity.

Since the increased number of shoots after the third defoliation may have been due to chance, a further trial was considered necessary.

Plants 12 months old grown from seed under controlled conditions in the greenhouse, which had been growing in boxes out of doors for 8 months, were used. The roots were washed clean of all soil and carefully dried on blotting paper, and then weighed and planted in boxes of soil in the greenhouse. Four plants in this case were subjected to each intensity of defoliation and kept under conditions as nearly as possible identical with those of the first trial.

Before the first defoliation the plants were grown undisturbed for 3 weeks to become acclimatised to greenhouse conditions and to obtain a firm hold in the soil. The trial was started at the end of November 1937, continuing to the beginning of March, 1938.

Before each defoliation the number of shoots on the plants of both species were noted. Three weeks after the last defoliation the plants were lifted and weighed. The data for *Rumex obtusifolius* are given in Table VII.

The gradual decrease in weight from the control plants to those subjected to defoliation five times agrees with the first trial. There is a slight difference in the time when the greatest number of shoots are produced. In the first trial most shoots were produced after the third defoliation, but in the second trial it is after the second cutting that most shoots are produced, the number falls slightly after the third defoliation, rapidly after the fourth, but increases again after the fifth defoliation.

These differences may be attributed to differences in age between the plants of the first and those of the second trial, or, to the fact that the former plants were kept throughout their life period under greenhouse conditions, whilst the latter spent three quarters of their lives out of doors, or finally to the times of the year during which the trials were carried out, in the first trial from the end of

TABLE VII.

Box number	Plant	Initial weight (gms.)	Final weight (gms.)	*No. of shoots at each defoliation*					
				1st cut	2nd cut	3rd cut	4th cut	5th cut	3 weeks later (lifted)
1. Control	A.	10.0	92.0	1	1	1	1	1	1
	B.	7.5	43.0	1	1	1	1	1	2
	C.	10.0	73.0	1	1	1	1	1	1
	D.	9.5	46.0	1	1	1	1	1	1
Average		9.25	63.5	1	1	1	1	1	1
2. Cut once.	A.	6.5	13.0	1	1	1	1	1	1
	B.	9.5	50.0	1	1	1	1	1	1
	C.	7.0	52.0	1	1	1	1	1	1
	D.	9.5	57.0	1	1	1	1	1	2
Average		8.1	43.0	1	1	1	1	1	1
3. Cut Twice	A.	7.5	21.0	1	5	6	6	6	8
	B.	9.5	55.0	1	1	4	5	6	6
	C.	9.5	45.0	1	1	1	1	1	4
	D.	9.5	16.0	1	3	4	4	4	7
Average		9.0	34.25	1	2	4	4	4	6
4. Cut 3 times.	A.	10.0	18.0	1	1	1	1	1	2
	B.	9.5	30.0	1	1	1	1	3	5
	C.	6.5	10.0	1	1	1	3	4	7
	D.	12.0	26.0	1	1	1	1	1	2
Average		9.5	21.0	1	1	1	1	2	4
5. Cut 4 times.	A.	10.5	13.0	1	1	1	1	1	1
	B.	9.5	11.0	1	2	2	1	1	1
	C.	7.5	10.0	1	1	1	1	1	1
	D.	10.5	11.0	1	1	1	1	1	1
Average		9.5	11.25	1	1	1	1	1	1
6. Cut 5 times.	A.	7.5	7.0	1	8	8	5	7	7
	B.	10.0	7.0	1	1	1	1	1	1
	C.	9.5	8.0	1	5	8	7	7	9
	D.	8.0	6.0	1	1	1	1	1	1
Average		8.75	7.0	1	4	4	3	4	4

June to the beginning of October 1937, and in the second trial from the end of November 1937 to the beginning of March 1938, but it may be that all three conditions are working collectively and not independently.

Table VIII shows the data for the second trial on *Rumex crispus*. This gives the fall in weight from the control plants to those defoliated five times, which agrees with the first trial, but is not as regular as in *Rumex obtusifolius*.

There is no increase in the number of shoots until after the

TABLE VIII.

				No. of shoots at each defoliation					
Box number	*Plant*	*Initial weight (gms.)*	*Final weight (gms.)*	*1st cut*	*2nd cut*	*3rd cut*	*4th cut*	*5th cut*	*3 weeks later (lifted)*
1. Control.	A.	19.0	36.0	1	1	1	1	1	1
	B.	11.0	50.0	1	1	1	1	1	1
	C.	13.0	36.0	1	1	1	1	1	1
	D.	9.0	21.5	1	1	1	1	1	1
Average		13.0	35.8	1	1	1	1	1	1
2. Cut once.	A.	18.0	46.0	1	1	1	1	1	1
	B.	10.0	30.0	1	1	1	1	1	1
	C.	10.0	28.0	1	1	2	2	1	1
	D	13.0	29.0	1	1	1	1	1	1
Average		12.7	33.25	1	1	1	1	1	1
3. Cut 3 times by mistake.	A.	20.0	27.0	1	1	2	3	3	3
	B.	11.0	30.0	1	1	2	2	2	2
	C.	14.0	47.5	1	1	4	2	2	3
	D.	10.0	23.5	1	1	1	1	1	1
Average		13.75	32.0	1	1	2	2	2	2
4. Cut 4 times.	A.	18.0	36.5	1	1	3	3	3	2
	B.	14.0	40.5	1	1	3	4	4	5
	C.	9.0	19.5	1	1	1	2	3	2
	D.	10.0	44.5	1	1	3	3	3	6
Average		12.75	35.25	1	1	2	3	3	4
5. Cut 5 times.	A.	13.0	27.0	1	1	3	6	6	8
	B.	14.0	36.5	1	1	3	4	2	1
	C.	9.0	23.5	1	1	1	1	1	1
	D.	11.0	23.5	1	1	3	4	3	3
Average		11.75	27.6	1	1	2	4	3	3
6. Cut 6 times.	A.	14.0	18.5	1	1	2	2	1	1
	B.	17.0	21.0	1	1	1	4	3	2
	C.	9.0	9.5	1	1	3	3	1	1
	D.	12.0	16.0	1	1	2	5	3	1
Average		13.0	16.25	1	1	2	3	2	1

second defoliation. The total number of shoots increase up to the fourth but decrease with subsequent defoliation.

This is further confirmation that up to a certain stage defoliation induces a greater number of shoots to be produced, further defoliation decreasing the number. This fact should be borne in mind when defoliation is used as a means of eradication, since abandonment of defoliation before the roots are completely exhausted might lead to a worse state of affairs than before its commencement.

It has been clearly shown that defoliation is an effective and adequate method for the eradication of *Rumex obtusifolius* and *Rumex crispus* under trial conditions. Under field conditions, however, it cannot be generally practicable except as a means of checking them, because it would be difficult with a mowing machine to remove all the leaves and ensure the complete defoliation called for. Generally, Docks are found scattered singly in fields, and it is rarely one finds fields so badly infested with them that it would need a mowing machine for their cutting.

Correlation of Depth of Planting Regenerative Portions with Establishment in *Rumex obtusifolius* and *Rumex crispus*.

An attempt was made here to ascertain whether it is feasible in the field, by ploughing, to bury portions of dock stems at depth from which they will not be re-established.

Pieces of vegetative stems from fresh plants of both species were planted in boxes of soil in the greenhouse at depths of 3, 4, 5 and 6 inches respectively.

The plants were lifted 70 days from planting, and it was observed that the new shoots had elongated stems, the internodes being greatly lengthened, as opposed to the truncated vegetative stem on normal Dock plants planted at their normal depth.

The condition of the plants on lifting is shown in Table X.

Out of 8 pieces planted, 4 have established plants, the largest piece, although at the greatest depth, appearing in the shortest time (Table IX.)

The deeper the planting the greater is the length of elongated stem produced, but this varies, for example, in the 4 inch depth, two pieces of equal dimensions, the plant in Row A. having a stem 1.0 cm. long, whilst in the Row B plant the stem is 5.8 cm. long; both bear two leaves, but the former appears four days before the

TABLE IX.

Rumex obtusifolius.

Depth of planting (inches)	*Row A.*			*Row B.*		
	Length (cms)	*Diameter (cms)*	*Number of days for appearance*	*Length (cms)*	*Diameter (cms)*	*Number of days for appearance*
3	2	1½	36	2	1	—
4	2	1½	32	2	1½	36
5	2	2	—	2	1½	—
6	2	2½	31	2	1½	—

latter. This was due to plant in Row A. concentrating its lengthening in the petiole, which grows at a faster rate than the stem in the Row B plant.

TABLE X.
Rumex obtusifolius.

Depth of of planting (inches)	*Row A*			*Row B*		
	No. of shoots	*No. of leaves*	*Length of stem (cms)*	*No. of shoots*	*No. of leaves*	*Length of stem (cms)*
3	1	3	1.6	2 shoots started growth.	—	1.0* 2.6*
4	1	2	1.0	1	2	5.8
5	1 shoot started growth	—	10.0*	2 shoots started growth.	—	4.0* 4.5*
6	1	2	9.0	6 buds just commencing growth.	—	—

*=Total length of shoots.

TABLE XI.
Rumex crispus.

Depth of planting (inches)	*Row A.*			*Row B.*		
	Length (cms)	*Diameter (cms)*	*Number of days for appearance*	*Length (cms)*	*Diameter (cms)*	*Number of days for appearance*
3	2	1½	18	2	1	22
4	2	1½	16	2	1½	24
5	2	2	21	2	1½	34
6	2	2½	30	2	1½	34

The condition of these plants on lifting is shown in Table XII.

TABLE XII.
Rumex crispus.

Depth of planting (inches)	*Row A.*			*Row B.*		
	No. of shoots	*No. of leaves*	*Length of stems (cms)*	*No. of shoots*	*No. of leaves*	*Length of stems (cms).*
3	3	4 each	1.6 1.7 2.1	2	3 each	1.6 2.0
4	3	4 each	2.5 2.5 5.2	1	4	3.5
5	1	4	6.2	1	4	8.1
6	1	4	11.0	1	4	9.1

All 8 pieces established plants in a much shorter time than did *Rumex obtusifolius* of the same size (see Tables IX and XI).

This species shows more clearly that the length of the stem and the time required for appearance above the soil increases with the depth of planting.

The ' A ' series of plants, established from slightly larger pieces of regenerative tissue than the ' B ' series, on the whole are bigger and stronger than the latter. This again shows that the size of the regenerative pieces governs the size of the plant produced from it.

The plants of *Rumex obtusifolius* produced from regenerative pieces equal to those of *Rumex crispus*, have thicker and more succulent stems and petioles than the latter, but this is also the case in normal plants.

The above trials clearly show that even small pieces of regenerative tissue must be buried deeper than 6 inches to prevent re-establishment.

In order to ascertain the maximum depth from which re-establishment is possible, another set of regenerative pieces from both species were planted at depths of 9, 10, 11 and 12 inches. Tables XIII and XIV give the approximate dimensions of the pieces.

TABLE XIII.

Rumex obtusifolius.

Depth of planting (inches)	*Row A.*			*Row B.*		
	Length (cms)	*Diameter (cms)*	*Number of days for appearance*	*Length (cms)*	*Diameter (cms)*	*Number of days for appearance*
9	2.1	1.2	No appearance after 60 days	2.0	1.0	No appearance after 60 days.
10	2.4	1.3		2.2	1.1	
11	2.2	1.4		2.3	1.1	
12	2.5	1.5		2.3	1.1	

TABLE XIV.

Rumex crispus.

Depth of planting (inches)	*Row A.*			*Row B.*		
	Length (cms)	*Diameter (cms)*	*Number of days for appearance*	*Length (cms)*	*Diameter (cms)*	*Number of days for appearance*
9	2.0	1.3	No appearance after 60 days.	2.0	1.3	No appearance after 60 days.
10	2.0	1.5		2.0	1.0	
11	2.0	1.7		2.0	1.0	
12	2.1	1.6		2.0	1.2	

The condition of these plants on lifting is shown in Tables XV and XVI.

TABLE XV.

Rumex obtusifolius.

Depth of planting (inches)	*Row A.*		*Row B.*	
	Number of shoots.	*Length of shoots. (cms)*	*Number of shoots.*	*Length of shoots. (cms)*
9	2	2 ; 4	3 (withered)	2 cms each
10	2 (withered)	7 ; 8	Regenerative piece dead.	—
11	1	11	2	2 ; 12.5
12	1	12.5	3 (withered)	4 ; 5 ; 8

TABLE XVI.

Rumex crispus.

Depth of planting (inches).	*Row A.*		*Row B.*	
	Number of shoots.	*Length of shoots (cms)*	*Number of shoots*	*Length of shoots (cms)*
9	Regenerated tissue dead	—	3	14 ; 16 ; 20
10	1 (withered)	8	0	-
11	1	16	0	...
12	1	23	1	14

Comparison of Tables XV and XVI shows that at 11 and 12 inch depths the *Rumex crispus* pieces have made better progress, although of slightly smaller size than *Rumex obtusifolius* pieces. It is possible that had this trial been left undisturbed for another 20 days a few of the regenerative pieces would have established plants.

The foregoing trials show that to prevent establishment from even small fragments of Dock plants they must be buried deeper than 12 inches. Further, the size of the fragment governs the size of the new plant up to a point, presumably because the larger the fragment the greater amount of food reserves it contains. This fact shows that an entire plant would have to be planted at a very great depth to ensure failure to re-establish.

Ploughing as a means of eradication in itself, by deep burial, is impracticable since the normal depth of ploughing is roughly 6—8 inches, and even small pieces of regenerative tissue can establish themselves from this depth.

Desiccation of *Rumex obtusifolius.*

An attempt was made to estimate how long, in the case of *Rumex obtusifolius*, plants could withstand desiccation when the roots were not covered by soil.

Eighteen fresh entire plants were washed clean of soil, and dried on blotting paper. They were then weighed and hung up to dry on the wall of a warm room, to be weighed and planted in the greenhouse in series at intervals of two weeks from the middle of February 1937. Three plants were planted at the end of each fortnight's interval for a period of three months.

Of the entire series, only two plants were successful in re-establishing themselves. These had been subjected to but a fortnight's desiccation, during which they had lost 63 % of their original weight. The time taken for re-establishment was 22 days in the case of the heavier plant (71 gms. fresh weight) and 31 days in the case of the smaller plant (fresh weight 55 gms.) The third plant of the same lot in the series (45.4 gms. fresh weight) failed to establish itself after losing 69 % of its fresh weight. Obviously desiccation in this case had proved lethal.

Under the conditions of drying viability is impaired very soon, for the intensity of desiccation that sets in shortly after the first fortnightly period completely impairs the chance of recovery of the plant in the soil as seen from the following figures :—

TABLE XVII.

Desiccation of Rumex obtusifolius indoors.

Weeks of desiccation.	*Average % loss in weight of plant in group.*	*Time taken for re-establishment if any.*
2	61.9 64.6 68.4 63.4	One plant in 22 days. One plant in 33 days. One plant no establishment
4	71.3	No establishment.
6	70.2	
8	72.3	
10	71.1	
12	72.5	

A further trial was carried out in an attempt to reconstruct natural conditions prevailing in the field during the season of Spring cultivation. The plants were laid on the surface of cultivated soil, out of doors, during April and May. Conditions here differ from those pertaining to the test indoors in that the plants would benefit from the incidence of rainfall and the condensation of dew at night

The plants were obtained from the same vicinity and treated in exactly the same manner with regard to washing, as in the previous trial, but they were desiccated outside.

The trial was continued over two months, batches of five desiccated plants being weighed at the end of each week and planted in soil, adjacent to where they were desiccated, and notes being made of the weather conditions for each week.

Here, also, out of doors, desiccation serious enough to impair the chance of re-establishment can be assured in a short interval of time. Out of the 40 plants included in the trial, only three succeeded in becoming re-established, and these were of the first series subjected to dessication for one week only. The remainder rotted away in the soil.

TABLE XVIII.

Desiccation of Rumex obtusifolius out-of-doors.

Weeks of desiccation	*Average % loss in weight of plants in group*	*Time taken for re-establishment if any.*	*Weather conditions.*
1	50.9 { 40.3 39.7 65.4 47.4 61.8	16 days 16 days No establishment 35 days No establishment	Warm, occasional light showers, mainly dry.
2	58.5	No establishment	Frequent showers, cold, mostly dull.
3	58.0		Heavy rain on one day, but mainly dry. Hot at the beginning, becoming cold at the end of the week.
4	54.9		Showers, with equal periods of sunshine.
5	67.6		Heavy rain at first, followed by showers, Fairly warm.
6	69.5		Dull and dry; some bright periods.
7	66.6		Mostly bright and warm. Rain last two days.
8	57.1		Dull and rainy. Very little sunshine.

The largest plant (fresh weight 50.2 gramms) lost 40.3%, and the smallest (fresh weight 25.5 gramms) 48.6% of its fresh weight after one week's dessiccation. The former established itself in 16 days, and the latter in 35 days.

The two plants (fresh weight 29.5 and 18.5 gramms), in the same batch, which failed to re-establish themselves lost respectively 65.4 and 61.8% of their fresh weight, which is considerably more than that lost by the re-established plants (see Table XVIII).

As one would expect, the smaller plants undergo a greater proportional loss in weight over the same period of desiccation than do the larger plants.

The weather during the first week of the trial was warm, with occasional light showers, but mainly dry. It is reasonable to suppose that, given similar weather for two consecutive weeks after harrowing, the small and medium sized Dock plants would be desiccated, or at least considerably retarded, thereby giving the crops a good start with the possibility of choking them out.

It is seen that a spring fallow of a fortnight's duration, provided that the weather be fairly dry, will materially check Docks.

Summary and Conclusions.

A short description of the seedling morphology of three *Rumex* species and of the anatomy of the vegetative stems and the roots of two Dock species are given. The extent of the juvenile stage in each is indicated and the greater effectiveness of the application of control measures in the vulnerable pre-establishment condition is emphasized.

In the Docks it is established that vegetative reproduction is confined to the vegetative stem portions alone (from buds already formed). The existence of root buds in Docks is disproved, and the much quoted belief in root regeneration discredited.

Spudding of Docks at a depth of one inch only serves to temporarily check the plants, more shoots being thrown up later from lateral buds. Spudding at two-inch depth is more drastic, some failing to recover, while others that survive may take over a month to restart growth. Spudding at four inches eradicates all plants of these species.

Defoliation, though impracticable in the field, except as a means of checking, is an effective and adequate method of control if persisted in. The countryman's belief that Docks thrive on cutting is discussed. The results show that abandonment of defoliation before the roots are completely exhausted may lead to a state of affairs worse at the end than at the start, since for a time the number of shoots increase with defoliation. Maximum shoot production occurs in plants subjected to two or three defoliations, and to be effective, defoliation must be persisted with beyond this.

Regeneration of Docks from small stem fragments has been effective to an observed soil depth of one foot. Ploughing as a means of control is thus quite ineffective.

Desiccation of the entire plant on the soil surface at the time of spring cultivation for a period of ten days to a fortnight offers very effective control, as viability is seriously impaired under these conditions.

A BOTANICAL SURVEY OF THE PASTURE AND HAY FIELDS ON BRYNAMLWG FARM, ABERYSTWYTH.

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This paper deals with a botanical survey of seven fields, aggregating some thirty acres, and representing that part of Brynamlwg Farm which came into the occcupation of the Welsh Plant Breeding Station on October 1st, 1938.

The survey was primarily undertaken so that records would be available for future use relative to the type of herbage grown on the farm. The data collected also serve to show the botanical composition of pasture and hay fields on a farm reasonably typical of the Aberystwyth district and the lowlands of Cardiganshire generally.

Brynamlwg Farm lies a little more than a mile to the north-east of the town of Aberystwyth ; it has a general westerly aspect overlying the town and lies between the 900 and 250 contours. The farm is completely exposed to the prevailing winds from the south and west ; the soil is a stony medium loam of no great depth and with good natural drainage, the underlying rock being of the Lower Silurian Age belonging to the Aberystwyth Grits in the Tarrannon Series (1).

The survey was conducted during September, 1938. The method of herbage analysis adopted for each field was largely determined by the amount of growth present in the field ; thus where the herbage was of no great length, 2-3 inches, the percentage area covered estimation method (2) was used, while in fields where the herbage was taller the percentage productivity method was employed. Where the latter method was found practicable, samples were taken at intervals of six yards along the two diagonals of the field concerned. The herbage so collected was separated into different species present and the results were expressed as percentages by weight of the whole.

Reference to the plan and its legend (Fig. 1) shows the location of the seven fields named respectively Hawthorn Field, Middle Field, East Field, Reservoir Field, The Slope, Copse Field and The Paddock. The results obtained for individual fields are discussed below.

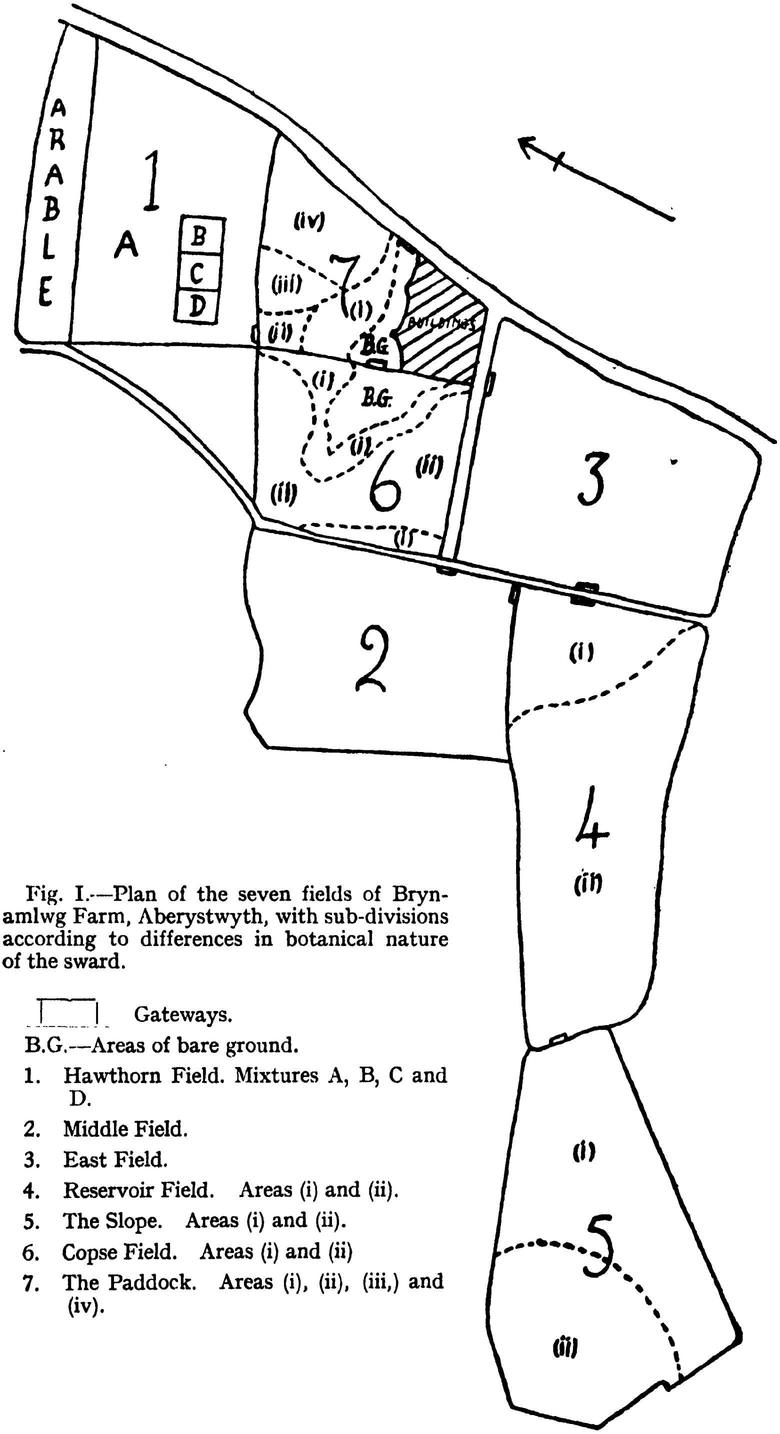

Fig. I.—Plan of the seven fields of Brynamlwg Farm, Aberystwyth, with sub-divisions according to differences in botanical nature of the sward.

Gateways.

B.G.—Areas of bare ground.

1. Hawthorn Field. Mixtures A, B, C and D.
2. Middle Field.
3. East Field.
4. Reservoir Field. Areas (i) and (ii).
5. The Slope. Areas (i) and (ii).
6. Copse Field. Areas (i) and (ii)
7. The Paddock. Areas (i), (ii), (iii,) and (iv).

Discussion of Results.

1. HAWTHORN FIELD (ANALYSED 5/9/38).

Previous to 1934 a strip of this field along the southern side has been under arable cropping, the remainder being in grass; the whole area was ploughed in 1934 and laid down immediately to grass in consultation with the Welsh Plant Breeding Station. A strip of approximately a quarter of an acre adjacent to the northern hedge (Fig. 1) was retained for arable cropping. The seeds were sown under spring oats on April 5, 1934, using four mixtures which differed only with regard to the strain of perennial rye grass included in each case. The main area of two and a half acres was sown with Mixture A, containing the pasture strain of perennial rye-grass, S.23; in addition there were three one-eighth acre blocks sown respectively with Mixture B containing the hay strain of perennial rye-grass, S.24, Mixture C (pasture hay strain of perennial rye-grass S.101), and Mixture D (commercial perennial rye-grass). The seed rates used were identical and are given in Table I.

TABLE I.

Showing the composition of the seeds mixtures sown on Hawthorn Field in 1934.

Species.	*lb. per acre.*
Lolium perenne (perennial rye-grass)	20
Cynosurus cristatus (crested dogstail)	1½
Poa trivialis (rough-stalked meadow grass)	2
Trifolium pratense (Montgomery red clover)	3¼
T. repens (white clover)	3

From 1935 to 1938 inclusive, the field was put up to hay each year, and the aftermath grazed. No artificial manures were applied throughout the whole of this period, but farmyard manure was applied liberally in each year.

At the time of analysis, the northern side of Hawthorn Field was still in arable cropping, while the remainder in grass consisted of leafy aftermath which had not been grazed since taking hay in July, the herbage varying in height from 12 to 18 inches. The field was fairly weedy throughout, docks being prevalent, especially towards the south-west corner. The major portion of the sward consisted of Yorkshire fog and perennial rye-grass, together with a variety of other grass species (Table II); white clover provided some 21.5 per cent of the herbage, while red clover only contributed 0.5 per cent, and was not general in its distribution in the sward.

Weed species present were silverweed, creeping thistle, dandelion, hogweed, ribgrass, greater plantain, knapweed, *Geranium molle*, *Crepis* sp. purple vetch, yarrow, red *Bartsia*, black bindweed, mouse-ear chickweed, daisy, creeping buttercup and sorrel, the two plantains being fairly general throughout.

Method of Analysis.

No account was taken of the different mixtures originally sown, and as excessive growth prevented the percentage area estimation method being used samples of the herbage were taken and analysed by the percentage productivity method.

The results of analysis (Table II, column 1) show that the three main contributors to the sward in regard to productivity were Yorkshire fog (21.0 per cent), perennial rye-grass (21.0 per cent), and white clover (21.5 per cent). Cocksfoot, bent grass, couch, rough-stalked meadow grass and weeds were much lower in their percentage productivity, and ranged from 3.5 to 9.0 per cent, while *Poa annua*, smooth-stalked meadow grass, sweet vernal, tall oat grass, red fescue, meadow foxtail, timothy, Italian rye-grass and red clover each contributed from a trace (T) to 2.5 per cent.

2. MIDDLE FIELD (ANALYSED 8/9/38).

No information is available as to when this field was laid down to grass, but it has evidently been down for many years. From 1934 to 1938, inclusive, it was put up for hay and the aftermath grazed. During the 1934-38 period no artificial fertilizers were applied, but farmyard manure similar to that used in the case of Hawthorn Field had been liberally used.

As a whole this field was fairly uniform in its botanical composition ; at the time of analysis the aftermath had been leniently grazed, the growth of the herbage being from four to five inches in height. Weeds were prevalent throughout, especially around the two gateways on the eastern and southern sides respectively where *Plantago major* dominated. In the main area the weed species were creeping buttercup, *Plantago* spp. yarrow, sorrel, creeping thistle, this last being general in distribution, although rather more frequent towards the north-east corner.

The grasses were not very numerous in so far as the number of different species present was concerned, but were fairly evenly distributed. Yorkshire fog and bent grass were the two co-dominants, with others shown in Table II (column 2) less frequent, in occurrence.

White clover was the only clover species noted, and although it contributed a fair bulk to the general herbage, the coarseness of growth of other species, coupled with the fact that the field had been

TABLE II.

The percentage botanical composition of the Brynamlwg Fields on a percentage area covered estimation basis. Miscellaneous weeds for individual fields are noted in the text.

Species.	*Average of two diagonals Percentage productivity.*			*Percentage area covered.*						*Percentage productivity.*			
	1. Hawthorn Field.	*2 Middle Field.*	*3. East Field.*	*4. Reservoir F.*		*5. The Slope.*		*6. Copse F.*		*7. The Paddock.*			
				Area (i)	*Area (ii)*	*Area (i)*	*Area (ii)*	*Area (i)*	*Area (ii)*	*Area (i)*	*Area (ii)*	*Area (iii)*	*Area (iv)*
Lolium perenne	21.0	8.8	10.0	10.0	7.0	3.0	1.0	—	8.5	15.0	9.7	6.5	13.7
L. italicum	T	T	—	—	—	—	—	—	—	—	—	0.5	—
Dactylis glomerata	3.5	3.3	1.6	1.0	0.5	1.0	7.0	—	9.5	—	12.5	9.6	0.4
Phleum pratense	0.5	—	—	—	—	—	—	—	—	—	—	—	—
Alopecurus pratensis	0.5	0.5	0.25	—	—	—	—	—	T	—	1.2	T	0.3
Cynosurus cristatus	—	0.3	T	2.0	1.0	1.0	4.0	—	4.5	1.0	T	0.4	5.0
Poa trivialis	7.5	8.5	4.1	1.0	4.5	10.0	2.5	—	12.5	5.5	7.5	1.2	3.4
P. pratensis	T	—	—	—	—	1.0	—	—	0.5	T	0.7	0.7	0.2
Festuca rubra	2.5	5.8	5.0	—	5.0	6.0	5.5	—	5.5	—	3.1	10.6	7.6
Holcus lanatus	21.0	29.3	36.0	T	24.0	29.0	4.5	—	0.5	—	34.8	14.7	29.0
Agrostis sp.	3.5	28.4	37.7	7.0	41.5	43.5	54.0	T	34.0	17.5	15.4	45.5	24.0
Poa annua	1.0	—	—	59.5	—	—	—	98.5	18.0	34.0	T	T	0.2
Anthoxanthum odoratum	1.0	0.3	T	—	5.0	T	4.0	—	—	—	T	T	3.5
Agropyrum repens	4.5	—	—	—	—	T	—	—	—	—	—	—	—
Festuca arundinacea	—	—	—	—	—	T	—	—	0.5	—	—	—	—
Bromus mollis	—	—	—	—	—	—	—	—	T	—	—	0.2	—
Arrhenatherum elatius	2.5	—	—	—	—	—	—	—	—	—	—	T	0.2
Trisetum flavescens	—	—	—	—	—	—	—	—	T	—	—	—	—
Trifolium pratense	0.5	—	—	—	—	—	—	—	—	—	—	—	—
T. repens	21.5	10.1	2.4	14.5	6.0	3.5	7.5	0.5	3.5	17.0	6.7	3.1	4.3
Miscellaneous weeds	9.0	4.7	3.05	5.0	5.5	2.0	10.0	1.0	2.5	10.0	8.4	7.0	8 2

put up to hay each year, provided conditions adverse to its growth and spread.

The sward may, however, be referred to as a Yorkshire fog—bent—white clover type, containing a small percentage of miscellaneous weeds which did not comprise any great variety of species.

Method of Analysis.

The method of analysis used was similar to that for Hawthorn Field, the samples being taken along the two diagonals, and the results expressed on the basis of percentage productivity are shown in Table II, column 2.

These results show an average of 29.3 per cent of Yorkshire fog, 28.4 per cent of bent sp., these being the two dominant species. with white clover at 10.1 per cent, although as pointed out above, this percentage of white clover would be somewhat lower on a percentage area covered method of analysis. Perennial rye-grass, rough-stalked meadow grass, red fescue, cocksfoot and weeds were the other main contributors, aggregating 31.1 per cent of the total herbage.

3. EAST FIELD (ANALYSED 12/9/38).

The actual date of laying down to grass is not known, although here again the sward was fairly old. The field was put up to hay each year from 1934 to 1938, inclusive, the aftermath being grazed. No artificial fertilizers were applied, but liberal dressings of farmyard manure were also given in this case.

At the time of analysis, aftermath growth varied in height from four to five inches, except for certain portions of the area where growth exceeded this, due to the coarseness of the herbage present and the subsequent lack of proper grazing in the aftermath. Apart from the *Plantago major—Senecio vulgaris* dominant areas around the western and northern gateways the field was fairly uniform in botanical composition, although towards the north gate and the south-west corner bent grass did become more pronounced.

Weeds were numerous in the number of their different species, but did not take up any great area in the sward itself. The more important of these were dandelion, yarrow, *Plantago* spp. hogweed, sorrel, hawkweed, creeping buttercup, dock, daisy selfheal and mouse-ear chickweed. Creeping thistle also occurred along the headlands, although it was not so generally distributed in the sward as on Middle Field. The range in the variety of grass species was not very great, the main ones being bent grass, Yorkshire fog and perennial rye-grass. White clover was not well established and did not contribute to any degree. Some red clover was present.

Method of Analysis.

The amount of growth present again necessitated the cutting of samples, as in Hawthorn and Middle Fields, and expressing the results of analysis on the basis of percentage productivity.

The results of analysis (Table II, Field 3), show that bent grass and Yorkshire fog were co-dominants, and these contributed 37.7 per cent and 36.0 per cent. respectively, with perennial rye-grass at 10.0 per cent. Other species, including grasses, white clover and weeds occupied only a small percentage of the sward individually, together making 16.4 per cent of the total.

4. RESERVOIR FIELD (ANALYSED 12/9/38).

This sward did not appear to have been ploughed for a number of years, but its exact age was not known. In previous years, apart from 1934, when the field was put up for hay, it was used for pasture purposes, no manure being applied from 1934-38 inclusive, either as artificial fertilizers or as farmyard manure.

The field was closely grazed and appears to have been used for paddocking cattle during part of the day in winter. This was suggested by the fact that around the eastern gateway the botanical composition of the sward was entirely different from that of the rest of the field, and was similar to that induced by treading and puddling of the ground during unfavourable weather and growth conditions. This area was a quarter to half an acre in extent (Fig. I.) and was dominantly a *Poa annua*-white clover sward, together with the other grass species shown in Table II, 4, Area (i) present in smaller proportions.

Miscellaneous weeds on this area were yarrow, *Plantago* spp. creeping buttercup, mouse-ear chickweed, dandelion, daisy and creeping thistle, the last being the main weed species over the whole field and rather prevalent throughout.

The main body of the field below this *Poa annua* area was again fairly well grazed, although the growth here was greater than in the latter area, both in density and height. It had the following weed flora: yarrow, mouse-ear chickweed, creeping buttercup, *Plantago* spp. hawkweed, daisy, sorrel, dandelion, dock and creeping thistle, the last being very prevalent.

The sward in this case had a greater variety of grass species, the main ones being bent grass and Yorkshire fog, together with those noted in Table II (Area ii. Reservoir F.) White clover, although present was not so well established as in the *Poa annua* area, where naturally colonization was much easier than in the dense bent-Yorkshire fog sward of the remainder of the field.

Method of Analysis.

As the two areas in this field differed to such an extent and were sharply demarcated from each other, they were also treated separately on analysis. The shortness of growth in both areas enabled the percentage area covered estimation method of analysis to be applied, and as previous inspection showed the two areas to be uniform botanically within themselves it was considered sufficient to take ten readings in each case, randomising such readings so as to comprise an even distribution in each area.

The results of analysis of Area (i) show that *Poa annua*, the dominant species, occupied 59.5 per cent of the total area, white clover 14.5 per cent, perennial rye-grass 10 per cent, with the remaining 16 per cent being contributed by cocksfoot, crested dogstail, rough-stalked meadow grass, bent grass and weeds.

On Area (ii), the main body of Reservoir Field, the dominant species was bent (41.5 per cent), with Yorkshire fog at 24 per cent sub-dominant, while the percentages of red fescue rough-stalked meadow grass, sweet vernal, white clover and weeds were similar, each ranging around 5 per cent of the total area, while cocksfoot and crested dogstail together made up 1.5 per cent of the total.

5. THE SLOPE (ANALYSED 19/9/38).

This field lies at the lower end of the farm and is the farthest away from the farm-house. Since 1934, and in all probability for a good many years previously, it had been used for pasture purposes, no hay crop being taken from 1934-1938, and no specific manures being applied. The herbage present was indicative of bad management of the grazing, resulting in coarse, unpalatable growth.

In botanical composition the field was not very uniform, especially in the major portion of the area towards the north-east gate, and spreading down to the south-west corner (Fig. I) where the flora was varied in type and consisted of a number of species, although in the main it was a bent-Yorkshire fog dominant sward. The other grass species present are noted in Table II (Area i) of the Slope.

The main body of the field will be referred to as Area (i), while the smaller portions in the north-west corner with a bent-dominant sward and not quite so varied in the number of other grass species present will be referred to as Area (ii).

Area (i) had denser growth than Area (ii), due partly to the differences in the dominant species and partly to the latter area being situated on a drier portion of the field where the underlying rock came near to the surface: thus it was poor in fertility and unable to hold moisture during dry weather, resulting in a bent-dominant sward, together with other grass species shown in Table II (Area (ii), The Slope).

On account of the denser growth on Area (i) the white clover present suffered severely from competition. Area (ii) where growth was less dense contained more white clover.

The number of different species of weeds was small; creeping thistle, spear thistle, creeping buttercup, dock and hawkweed being the chief among them. Creeping thistle was prevalent throughout the whole area. The headlands on all sides were extremely weedy, nettles and thistles being very vigorous in certain parts.

Botanically the field was divisible into two separate areas where the sward consisted of (i) bent grass and Yorkshire fog as the main species, and (ii) bent as the dominant species.

Method of Analysis.

The two areas in this field were analysed separately, although in both the percentage area covered estimation method was adopted. Twenty readings using the 6″ × 6″ mesh were taken on the relatively variable Area (i), while in Area (ii), where the sward was much more uniform, only ten readings were made. All readings were randomized over the whole area in question.

The results of analysis of these two areas are shown in Table II, Field 5, Areas (i) and (ii). In Area (i) bentgrass (43.5 per cent) was the dominant, with Yorkshire fog (29.0 per cent.) sub-dominant, while rough-stalked meadow grass occupied 10.0 per cent. of the sward. The remaining 17.5 per cent of the total area was made up of other grass species, white clover and weeds, with traces of sweet vernal, tall fescue and couch.

In Area (ii) bentgrass (54.0 per cent.) again was the dominant species, but compared with Area (i) there was far less Yorkshire fog (4.5 per cent). There was a small number of other species present, including a higher percentage of white clover and weeds, 7.5 and 10.0 per cent. as compared with 3.5 and 2.0 per cent respectively.

6. COPSE FIELD (ANALYSED 23/9/38).

Previous to 1936, when they were separated and fenced off, Copse Field and The Paddock were one field, and had been depastured for a number of years as far as could be ascertained. From 1934—1936 a large number of pigs were allowed to run over the whole of these two areas, but in 1936 the lower portion below the farm buildings was separated off into what is now known as Copse Field, and the pigs confined to this area, although some few were still kept in the upper portion (The Paddock).

The concentration of a large number of pigs upon the comparatively small area of Copse Field, and feeding them with slaughterhouse offals, has probably resulted in raising the standard of fertility of the field to a very high level. At the same time it resulted in the field being extremely variable, both in regard to the amount of herbage actually covering the ground and the botanical composition of that herbage. An area of ground approximately quarter of an acre in extent around the east gateway was bare of all herbage, and this was also the case along all the headlands where the concentration of the animals had been most dense.

The remainder of the field could be divided roughly into two main areas with regard to botanical composition (Fig. I). The first of these, Area (i), will be referred to as being the *Poa annua*-dominant zone. This zone occurred in two separate parts of the field, namely, (a) the portion surrounding the bare area around the east gateway, which had been severely trampled and uprooted by the pigs, and (b) the area along the bottom headland on the western side where the pigs again concentrated near the hedgerow. The dominant species in both these cases was *Poa annua* in almost pure association, apart from some bent, a little white clover, and a few weeds, such as groundsel.

Between these two zones of *Poa annua* there was an area (Area (ii)) not quite so badly disturbed by the pigs which had a more varied flora, although it was mainly bent-dominant. Other grass species present here are noted in Table II, Field 6, Area (ii), as also is white clover and a number of weeds, namely, red *Bartsia*, creeping buttercup, ribgrass, groundsel, creeping thistle, redshank and mouse-ear chickweed.

Method of Analysis.

On both Areas (i) and (ii) the percentage area covered estimation method of analysis was used, and as the two areas were uniform within themselves ten readings were sufficient in each case. In Area (i) which was separated into two portions of the field, the ten readings were spread over to cover each equally.

The results obtained showed clearly the dominance of *Poa annua* (98.5 per cent) on Area (i), with only a trace of bent grass, and a little white clover, and weeds aggregating 1.5 per cent of the total area.

On Area (ii), bent held the dominant position in the sward, (34.0 per cent), although *Poa annua* (8.00 per cent) still contributed appreciably. The greater variety of other grass species in Area (ii) made up 42.0 per cent of the total area, with traces of meadow foxtail, soft brome and golden oat grass, while white clover and weeds were still fairly low in their contribution, there being 3.5 and 2.5 per cent of each respectively.

7. THE PADDOCK (ANALYSED 24/9/38).

As noted above The Paddock was separated from Copse Field in 1936 and for the period 1934—1936 pigs had been allowed to run over the whole area. After 1936 it was used as a small general purpose paddock, so that the varied uses to which it had been put have had a considerable effect upon the nature of the sward present, which varied in botanical composition in different parts of even such a small area as this. Gorse bushes were spreading along the eastern and northern hedges, although as yet they had not encroached to any extent on to the field itself. Creeping thistle was fairly prevalent in the north-east corner, and was spreading through the coarse herbage along the northern and eastern sides.

Considering the field as a whole it could be divided roughly into four areas from a botanical viewpoint (Fig. I). The southern side of the field alongside the farm buildings was bare of vegetation.

Next to this bare area, and extending above the west gate, was a portion, referred to as the *Poa annua* area (Area (i)), which consisted of the more heavily trampled part of the field, having a short, closely grazed herbage dominantly *Poa annua*, along with a considerable proportion of white clover. Other grasses are noted in Table II, Field 7, Area (i), and the following were the weed species present : ribgrass, greater plantain, self-heal, daisy, mouse-ear chickweed, red *Bartsia*, dandelion, creeping thistle, groundsel (especially around the west gate), ragwort and nettles (in patches).

The second area (Area (ii)) was around the north gate where cocksfoot was fairly prevalent, with bent grass and Yorkshire fog. The cocksfoot was of a coarse clumpy nature. Other grass species are noted in Table II, Field 7, Area (ii). White clover made some contribution to the general herbage, but as growth of the grass was coarse and badly grazed the amount present was of little consequence Weed species included red *Bartsia* creeping thistle, dandelion, ribgrass, yarrow, creeping buttercup, dock and sorrel.

Alongside Area (ii) was a similar area, Area (iii). These two contiguous areas differed mainly with regard to the relative amount of cocksfoot. Yorkshire fog and bent grass were present in each case ; the former contained a greater proportion of bent and a smaller proportion of Yorkshire fog and cocksfoot than the latter. The herbage on Area (iii) was coarse in growth and badly grazed The other grass species and weeds present being similar to those of Area (ii) Table II, Field 7, Area (iii).

The fourth area of the Paddock (Area iv) occupied the remainder of the field and was a Yorkshire fog-bent dominant sward, rather better grazed than Areas (ii) and (iii). White clover was present only to a small extent, and traces of red clover were evident. Other grass species in Area (iv) are noted in Table II, Field 7, Area (iv), and weeds were similar to those of Areas (ii) and (iii), together with knapweed; creeping thistle was rather more prevalent in Area (iv) than elsewhere.

Method of Analysis.

Area (i) was analysed by means of the percentage area covered estimation method, but the excessive growth on Areas (ii), (iii) and (iv) necessitated their being analysed by taking random samples within each area, and the results of such analysis expressed on a percentage productivity basis.

The results in Table II, Field 7, show that in Area (i) the dominant species was *Poa annua* (34.0 per cent) while perennial rye-grass and bentgrass contributed 15.00 and 17.5 per cent respectively. The percentage of white clover was fairly high at 17.0 per cent, with weeds contributing 10.0 per cent.

Area (ii) was dominantly Yorkshire fog, 34.8 per cent, with bent grass and cocksfoot sub-dominant, 15.4 and 12.5 per cent respectively. The amount of perennial rye-grass was less here as compared with Area (i), 9.7 per cent compared with 15.0 per cent, as also was the case with white clover, 6.7 per cent compared with 17.0 per cent, while *Poa annua* contributed only a trace.

Area (iii) was bent-dominant (45.5 per cent) with Yorkshire fog contributing 14.7 per cent. The proportion of red fescue was 10.6 per cent, while perennial rye-grass and cocksfoot contributed 6.5 and 9.6 per cent respectively. The amount of white clover was 3.1 per cent, while the percentage of weeds was somewhat similar in Areas (ii), (iii) and (iv), being 8.4., 7.0 and 8.2 per cent respectively.

Area (iv) was a Yorkshire fog-bent dominant sward, 29.0 and 24.0 per cent respectively, with perennial rye-grass contributing 13.7 per cent, red fescue 7.6 per cent, crested dogstail 5.0 per cent, with white clover again low (4.3 per cent).

Summary.

The report describes a botanical survey carried out on Brynamlwg Farm, Aberystwyth, previous to the land being taken over by the Welsh Plant Breeding Station for experimental purposes.

The data obtained have been treated separately for each individual field, and so far as possible the history of the fields during recent years was ascertained from the previous tenant and his employees. These data have been embodied in the report.

Acknowledgments.

The survey was undertaken for reference purposes in connection with the future work of the Welsh Plant Breeding Station at the suggestion of Professor Sir R. George Stapledon and Mr. William Davies, whom the author wishes to thank for help and advice.

References.

1. Pugh, D. W. (1934). Soil survey of the Plant Breeding Station Farm, University College of Wales, Aberystwyth. Examination Thesis. (Unpublished.)
2. Davies, William. (1931). Methods of pasture analysis and fodder sampling. *Welsh Plant Breeding Station Report No.* 1.

THE CHEMICAL COMPOSITION OF THE SEED AND STRAW OF VARIOUS GRASSES.

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Introduction.

The chemical aspects of grass seed production have hitherto received very little attention and nothing approaching a complete analysis of the seeds of any of the grass species seems to have been attempted, although German workers have carried out partial analysis of some of the species (**1**). It is to be expected, however, that investigation of the chemical composition of the seed and straw of grasses may remove some of the prejudices encountered amongst farmers against the growing of grass seed crops. For instance, the idea that a crop of grass seed removes excessive quantities of manurial ingredients from the soil is quite prevalent. There is also little information available regarding the feeding value of the straw remaining after threshing out the seed.

Accordingly, the chemical analysis of samples of grass seeds grown under varying conditions at the Welsh Plant Breeding Station, has been undertaken and in addition many other samples have been obtained from commercial sources. The seeds obtained from the Station's stocks had been threshed with a specially constructed peripatetic thresher and except in the case of Timothy (*Phleum pratense*) had been cleaned with a machine consisting essentially of (a) a variable blower, (b) a set of reciprocating screens to make separations according to seed length (2). In the case of Timothy, a clover huller had to be used to remove the glumes and a special cylinder replaced the lower one in the thresher.

The samples of most seeds obtained from the Station, however, were found to contain appreciable quantities of light seed, and some species, such as Cocksfoot and the Fescues, contained a certain amount of fragments of panicle, two or more seeds being thus firmly attached together. The light seeds were removed by putting the samples twice through a small hand blower. The material blown away consisted almost entirely of sterile seeds. The seeds attached in twos and threes were separated previous to the blowing, by rubbing on a sieve of suitable mesh, which allowed only individual seeds to pass through. This treatment was adopted with all the samples of grass seed obtained through the Welsh Plant Breeding Station.

Those samples obtained from commercial sources, however, were analysed without any treatment, since their purity and germination capacity were guaranteed.

The chemical composition of grass seeds.

During the course of this investigation samples of seeds of each of the following species were analysed :—

(1)	Cocksfoot	*Dactylis glomerata.*
(2)	Timothy	*Phleum pratense.*
(3)	Italian Ryegrass	*Lolium italicium.*
(4)	Perennial Ryegrass	*Lolium perenne.*
(5)	Smooth stalked Meadow Grass	*Poa pratensis.*
(6)	Rough stalked Meadow Grass	*Poa trivialis.*
(7)	Sheeps Fescue	*Festuca ovina.*
(8)	Tall Fescue	*Festuca elatior.*
(9)	Red Fescue	*Festuca rubra.*
(10)	Meadow Fescue	*Festuca pratensis*
(11)	Crested Dogstail	*Cynosurus cristatus.*
(12)	Meadow Foxtail	*Alopecurus pratensis.*
(13)	Tall Oat Grass	*Arrhenatherum avenaceum.*
(14)	Golden Oat Grass	*Avena flavescens.*
(15)	Bent Grass	*Agrostis canina.*
(16)	Brown top	*Agrostis tenuis.*
(17)	Sweet Vernal	*Anthoxanthum odoratum.*

The " seed " analysed were the ordinary commercial seed which in the case of most of the above species contained varying amounts of material (glumes, etc.) attached to the actual caryopses. Thus Timothy " seed " has just a thin covering of glumes, whilst Meadow Foxtail "seed " consist of glumes, paleae and grain of one or more flowers. The samples of Sweet Vernal grass seed analysed, however, consisted of caryopses only.

The samples were obtained from several sources; some had been produced on the Station Farm (Frongoch), others were from the various seed production centres associated with the station, whilst samples were also obtained from seed firms, such as Gartons, McGill and Smith, and Suttons.

TABLE I.

Showing average percentage of moisture, nitrogenous constituents, fat, and ash in the various species of grass seed analysed.

	Percentage	*Percentage in Dry Matter.*					
	Moisture.	*Nitrogen.*	*Crude Protein.*	*Fat*	*Crude Fibre.*	*Sol. Carbs.*	*Ash*
Cocksfoot	9.41	2.84	17.70	8.49	15.8	62.46	5.54
Timothy	10.67	2.89	18.05	4.84	5.9	68.38	2.84
Perennial Ryegrass	10.34	1.98	12.40	2.89	12.3	67.53	4.89
Italian Ryegrass	10.46	1.97	12.32	2.62	10.9	69.64	4.52
Poa Pratensis	9.80	2.17	13.59	5.38	16.8	54.69	9.54
Poa Trivialis	10.42	2.74	17.10	3.91	10.3	61.52	7.20
Sheeps Fescue	9.81	2.72	17.01	3.50	18.6	54.74	6.13
Tall Fescue	9.76	2.37	14.78	2.73	14.1	61.81	6.63
Red Fescue	9.07	2.40	14.98	3.36	14.4	62.80	4.45
Meadow Fescue	10.56	2.17	13.54	2.46	12.3	67.75	3.39
Crested Dogstail	8.98	2.52	15.73	6.53	13.3	58.38	6.09
Meadow Foxtail	9.16	3.14	19.65	9.70	14.1	50.99	5.56
Tall Oat grass	8.50	2.31	14.34	7.47	12.6	59.98	5.58
Golden ,, ,,	6.65	3.19	20.00	14.90	14.9	43.25	6.95
Agrostis Canina	8.01	3.19	20.00	13.10	10.8	44.37	9.92
Agrostis Tenuis	7.92	3.16	19.75	12.65	8.3	52.43	6.84
Sweet Vernal	9.40	4.30	26.90	15.60	8.1	43.93	5.52

The average composition of the seed of each species is given in Tables 1 and 2. The figures in Table I show that the limits of variation of the moisture content of the different species are quite small—from 6.65 to 10.76 per cent.—the seeds of most species having a moisture content between 8 and 10 per cent. These figures are considerably lower than those generally quoted for the unground seeds which is from 12 to 15 per cent. (**3**). This lower moisture content is probably accounted for by the loss of moisture which takes place during the process of grinding, since the mill used is a rapid one and there is a certain amount of heating, as well as a strong draught.

The nitrogen content varies to a much greater extent, and it is worthy of note, that in general, the seeds of the species of least agricultural value, such as Oat grass, Agrostis species, Meadow Foxtail and Sweet Vernal grass contain the highest percentage of nitrogen. This may be compared with the observation that the vegetative portions of Meadow Foxtail and Golden Oat grass are richer in protein than the other grasses. (**4**). Sweet Vernal grass is outstanding in this respect, containing 4.3 per cent. of nitrogen. equivalent to approximately 27 per cent of crude protein. The larger seeds such as the Ryegrasses, the Fescues, Crested Dogstail and Tall Oat grass are comparable in protein content to the cereals, although even the lowest figure, that of Italian Ryegrass is slightly higher than the usual figure quoted for Wheat (12.0 per cent. crude protein) which is the cereal richest in this constitutent.

The fat content shows some correlation with the protein content, although Timothy and Smooth-stalked Meadow Grass are exceptional in that the former has a high protein content and low fat content, whilst in the latter this position is reversed. When compared with the fat content of cereals it is seen that grass seeds show remarkable variations in this respect. Many of the grass seeds, Ryegrasses and Fescues expecially, contain less fat than oats, but they are all richer than barley or wheat. The abnormally high fat content of the seeds of some of the less valuable species of grass suggest that richness in fat is an aid in the establishment of the seed at lower temperatures since these species can flourish at higher elevations. (**5**).

The crude fibre content of these seeds is not of any great significance except in so far as it gives an idea of the amount of glumes attached to the caryopsis. Timothy seed has a low fibre content compared with all the other species, and this is explained by the very small proportion of fibrous covering which the seed possesses.

The figures given for the soluble carbohydrates were obtained by difference in the usual way, and give a rough indication of the amount of starch present in the seeds, since starch is the most important carbohydrate present. (**5**). It is seen that the seeds richest in fat are poorest in carbohydrates, probably due to the fact that the fat replaces the carbohydrate to some extent in the nutrition of the young seedling.

The ash content of the seeds of various species shows quite a considerable variation—from 2.84 per cent. in Timothy to almost 10 per cent. in Agrostis Canina, but from Table II it is seen that this variation is largely accounted for by the variability of the silica content, since the percentage silica free ash is remarkably constant. Timothy is outstanding in containing a very small amount of silica (0.70 %) whilst Agrostis Canina contains almost 10 times as much.

On the whole, however, the mineral content of grass seeds is higher than that of the cereal grains and this is especially so in the case of lime (CaO) although the characteristic of cereal grains—a high ratio of phosphate (P_2O_5) to lime (CaO) is exhibited also by grass seeds. The superiority in chemical composition of the seeds

TABLE II.

Showing average percentage of ash and ash constituents in seeds of various grass species.

	Ash.	*Silica.*	*Silica free ash.*	*Phosphate.*	*Lime.*	*Potash.*
Cocksfoot	5.54	2.89	2.64	1.11	0.33	0.94
Timothy	2.84	0.70	2.14	0.93	0.23	0.86
Per. Ryegrass......	4.89	2.27	2.62	0.97	0.34	0.90
Italian Ryegrass	4.52	2.29	2.23	0.90	0.33	0.84
Poa Pratensis......	9.54	6.65	2.88	0.94	0.29	0.61
Poa Trivialis	7.20	4.07	3.13	0.95	0.49	0.90
Sheep Fescue	6.13	3.65	2.48	0.83	0.38	0.71
Tall Fescue	6.63	4.11	2.52	0.94	0.35	0.92
Red Fescue	4.45	2.05	2.40	0.93	0.30	0.78
Meadow Fescue	3.95	1.45	2.50	0.90	0.33	1.11
Crested Dogstail	6.09	3.74	2.35	1.02	0.32	0.70
Meadow Foxtail	5.56	2.86	2.70	1.11	0.29	0.84
Tall Oat grass	5.58	3.22	2.33	0.81	0.32	0.55
Golden ,, ,, ...	6.95	4.08	2.87	0.99	0.48	0.92
Agrostis Canina	6.92	6.43	3.48	1.29	0.52	0.97
Agrostis Tenius	6.84	4.16	2.68	1.27	0.40	0.44
Sweet Vernal	5.52	2.87	2.65	1.29	0.31	0.68

of the less valuable grasses is further borne out in the mineral content, at least in the lime and phosphate, although the potash tends to be lower. Thus Agrostis species contain about 1.28 per cent. phosphate and about 0.50 per cent. lime as compared with 0.94 per cent. phosphate and 0.34 per cent lime for the Ryegrasses.

When the natural habitat of the various species is considered it is found that there is no very close correlation between this and the chemical composition of the seed. Armstrong (**5**) classifies the species considered roughly as follows :—

(*a*) Chalk and Limestone formation.
  1. Sheeps Fescue.
  2. Golden Oatgrass.
  3. Crested Dogstail.

(*b*) Sandy Soils.
  1. Smooth-stalked Meadow Grass.

(*c*) Sandy sea shores
  1. Red Fescue.

(*d*) Stiff moist clays or wet soils
  1. Tall Fescue.
  2. Timothy.
  3. Meadow Foxtail.
  4. Rough-stalked Meadow Grass.
  5. Sweet Vernal Grass.

(*e*) Heaths and Moors.
- 1. Sheeps Fescue.
- 2. Agrostis Canina.

It has been found that the vegetatative parts of plants growing naturally on calcareous soils contain greater amounts of lime than those growing on non-calcareous soils, although this is not always the case. (6). It is seen from Table II that there is a tendency for this to be so in grass seeds. Thus the seed of Golden Oat grass and Agrostis species which tend to grow on calcareous soils have a higher percentage of lime than the other species, but the high lime content found in Rough-stalked Meadow Grass seems to be exceptional. On the whole, however, there does not appear to be any very close correlation between natural habitat and the amounts of the constituents estimated.

TABLE III.

Showing amounts of minerals removed in lb. per acre in the seeds of various grass species assuming the yields to be those given below.

	Assumed Yields in lb. per acre.	*Nitrogen*	*Phosphate*	*Lime*	*Potash.*
Cocksfoot	400	11.36	4.44	1.32	3.76
Timothy	400	11.56	3.72	0.92	3.42
Per. Ryegrass	500	9.90	4.85	1.70	4.50
Italian Ryegrass	500	10.83	4.95	1.82	4.62
Poa Trivialis	200	5.48	1.90	.98	1.80
Red Fescue	300	7.20	2.79	.90	3.12
Meadow Fescue	400	8.68	3.60	1.32	4.44
Crested Dogstail	500	12.60	5.10	1.60	3.50
Meadow Foxtail	200	6.28	2.22	.58	1.68
Agrostis	200	6.36	2.56	.92	1.41
Wheat	2000	28.40	18.60	1.20	10.60

The view that excessive amounts of plant nutrients are removed from the soil in growing a crop of grass seed is widely held amongst farmers. The figures in Table III which are calculated on the assumed yield in the first column however, suggest that there is little reason to believe in the correctness of this view. (The assumed yields are not average yields, but are yields which can be reasonably expected under ordinary circumstances). Higher yields than these quoted are often obtained but even if they were doubled, a possibility which is rather remote in most cases, the amounts of nitrogen, phosphate and potash removed would not approach the amounts removed by a good crop of Wheat (2,000 lbs. of grain per acre). It is only in the case of lime that the amount removed is comparable with that removed by a crop of Wheat. Moreover, it is usually only the seed which is taken away from the farm. The straw which, as shown later, contains the larger proportion of the minerals, usually remains on the farms, is fed to stock and most of the minerals are thus returned to the soil.

The Chemical Composition of Some Grass Straws.

During the years 1936 and 1937 samples of the straw of the following grasses were obtained for analysis, viz :—

1. Cocksfoot (*Dactylis glomerata*).
2. Timothy (*Phleum pratense*)
3. Perennial Ryegrass (*Lolium perenne*)
4. Red Fescue (*Fescue rubra*)

The "straw" obtained in each case was the portion that remained after threshing out the seed, so that in many of the Ryegrass samples an appreciable amount of Wild White Clover was present, since this had been sown with the seed crop. The samples taken from the thresher were of about the same bulk as the sheaves of cereals obtained with a "self-binder," and in order to get a representative sample, the whole was chaffed up into pieces about one-eighth of an inch long with a small chaff-cutter, and thoroughly mixed. A small portion of this chaff was then ground into a fine state of division for analysis.

TABLE IV.

Showing average percentage of nitrogen, crude protein, fat, crude fibre, soluble carbohydrates and ash in straws of certain grasses.

	Percentage Moisture.	*Percentage in the Dry Matter.*					
		Nitrogen.	*Crude Protein.*	*Fat*	*Crude Fibre.*	*Sol. Carbs.*	*Ash.*
Cocksfoot	...... 7.09	0.59	3.71	2.90	42.5	45.92	5.82
P. Ryegrass	...... 7.90	0.67	4.19	2.00	36.1	52.07	5.64
Timothy	...... 7.73	0.51	3.17	2.14	37.1	53.86	3.73
Red Fescue	...... 7.57	0.42	2.57	1.62	34.8	44.58	5.43

TABLE V.

Showing percentage of ash constituents in the straws of certain grasses.

	Ash	*Silica*	*Silica free ash.*	*Phosphate*	*Lime*	*Potash*
Cocksfoot	...... 5.82	1.75	4.07	0.29	0.47	1.91
P. Ryegrass	...... 5.64	2.09	3.55	0.35	0.46	1.90
Timothy	...... 3.73	1.47	2.26	0.26	0.29	1.50
Red Fescue	..... 5.43	2.58	2.85	0.24	0.27	1.83

Tables IV and V give the average chemical composition of the straw of each species analysed. It is seen that, the straw of Perennial Ryegrass is the richest in crude protein. This is no doubt largely accounted for by the presence of the Wild White Clover in many of the samples of this grass, as the samples containing no clover are definitely poorer in this respect. No separation of the clover present in some of the samples was made, however. Red Fescue is comparatively poor in crude protein, and so is Timothy, whilst Cocksfoot is intermediate between these and Perennial Ryegrass. The small amount of crude protein in Timothy straw is somewhat surprising considering the relish with which it is consumed by cattle compared with the straw of other species. It is also equally poor in minerals as compared with the other species, and the fibre content is not particularly low, so that its palatability may probably be due to some minor organic constituent, or the phsycial texture of the straw. These straws in general are seen to be similar in chemical composition to the cereal straws. Timothy and Cocksfoot straw have approximately the same percentage of crude protein as Oat and Barley straw, whilst Red Fescue straw is comparable to Wheat straw in its protein content.

The amounts of fat in Cocksfoot, Ryegrass and Timothy straw are very similar to each other and to those in Oat and Barley straw. Red Fescue is poorer in this constituent and more comparable to wheat straw. The fibre content of Timothy and Ryegrass straws are appreciably lower than those of Cocksfoot and Red Fescue and are correspondingly higher in soluble carbohydrates. The ash content of Timothy straw is much lower than the others and although this is partly accounted for by its poverty in silica, the phosphate, lime and potash are also lower than in Ryegrass and Cocksfoot. The differences in phosphate content of straws of the four species are not very great, but the lime content of Cocksfoot and Ryegrass is much greater than that of Timothy and Red Fescue. The richness of the Ryegrass straw in lime, however, is again probably due to the presence of clover in many of the samples of which the average was taken. Compared with the cereal straws, the grass straws, excepting Timothy, tend to contain more minerals. This superiority is more pronounced in the potash and phosphate content, the lime content being more or less similar.

As would be expected these mature straws are inferior to hay in chemical composition, being much poorer in protein and minerals and containing much higher percentages of fibre.

The comparison of the general chemical composition of the seed and the straw of grasses reveals the same characteristics as are found in the seed and straw of cereals. On the whole, the seed of grasses is characterised by its high content of soluble carbohydrates, crude protein and fat, and its poverty in minerals, with the exception of phosphate and possibly potash, whilst the straw largely consists of crude fibre and soluble carbohydrates, being poor in crude protein and fat.

When considering the feeding value of these straws, the limitations in assessing this from their chemical composition alone must be borne in mind. (7) However, it is probably safe to assume that the straws of Cocksfoot, Perennial Ryegrass and Timothy are comparable in feeding value to average Oat straw, whilst Red Fescue is more comparable to wheat straw.

To determine the amount of manurial ingredients taken up by grass straws from the soil the percentage of these ingredients in the straw was multiplied by the yields in lb. per acre. The results of this calculation are given in Table VI.

TABLE VI.

Showing weights of minerals removed (To the nearest lb.) in lb. per acre in an average crop of four grass straws.

	Yield in lb. per acre.	*(Dry Matter)*	*Nitrogen.*	*Phosphate.*	*Lime.*	*Potash.*
Cocksfoot straw	5,000	4.650	27	13	22	89
Per. Ryegrass straw	5,000	4.650	31	16	21	87
Timothy straw	6,000	5,500	28	14	16	83
Red Fescue straw	4,000	3,700	16	9	10	68
Wheat straw	4,500	4,000	14	8	14	30

In comparison with the figures obtained for the seeds of the corresponding species (see Table III) it is seen that the straw is by far the most important factor in the removal of minerals from the soil.

The straw of each species compared with the seed (Tables 1 and 2) takes up approximately twice as much nitrogen, three times as much phsophate, ten to twenty times as much lime and twenty-five times as much potash, as the seeds. For comparison the amount of these minerals removed by a crop of Wheat straw of 4,500 lb. per acre is given. Cocksfoot, Perennial Ryegrass and Timothy straws take up about twice as much nitrogen, phosphate and lime, as the Wheat straw and almost three times as much potash. Red Fescue, however, is very similar to Wheat straw except in the case of potash of which it takes up about twice as much. But it should be stated that Wheat straw is very poor in potash in comparison with the other cereals, and the amount of potash taken up by an average crop of Oat straw would more closely approximate that removed by grass straws.

TABLE VII.

Approximate weights of minerals in lb./acre removed from the soil by average crops of four grasses (straw plus seed) and by Wheat (straw plus grain.)

	Nitrogen.	*Phosphate.*	*Lime.*	*Potash.*
Cocksfoot Timothy or Per Ryegrass	40	20	20	90
Red Fescue	25	12	11	70
Wheat	40	30	15	40

From the above table it is seen that there is little foundation for the idea common amongst farmers that a crop of grass grown for seed needs an excessive amount of phosphatic manuring, since a crop of Wheat requires considerably more phosphate than grass.

On the other hand it would appear that a good supply of potash in the soil is of much greater importance for a crop of grass than for a Wheat crop.

Summary and Conclusions.

The chemical analysis of the seed and straw of a number of grasses has led to the following conclusions :—

(1) There are considerable differences in the chemical composition of the seed of the different species analysed.

(2) There appears to be little relation between the mineral content of the seeds, and the type of natural habitat in which the various species flourish.

(3) The seed of the agriculturally least valuable grasses tend to be the richer in crude protein, fat, phosphate and lime than the seed of the valuable species.

(4) The crude protein content of the seed of the grasses analysed is higher than that of cereal grains, and in most cases much higher.

(5) The mineral content of the grass seeds is on the whole higher than that of cereal grain and this is especially so in the case of lime.

(6) The high ratio of phosphate to lime characteristic of the cereal grains is also exhibited by the seeds of grasses.

(7) The amounts of minerals removed by the seed of grasses from the soil per acre is much less than those removed per acre by the grain of cereals, except in the case of lime.

(8) The straws of the grasses analysed are similar in chemical composition to the cereal straws, Timothy, Cocksfoot

and Perennial Ryegrass being comparable to Oat straw, whilst Red Fescue is more comparable to Wheat straw.

(9) The straw of grasses take up much greater quantities of minerals from the soil per acre than do the seed of the same species.

(10) Cocksfoot, Timothy and Perennial Ryegrass straws take up about twice as much minerals from the soil per acre as an average crop of cereal straw.

(11) Grass straws require much more potash per acre for their sustenance than do the cereal straws.

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References.

1. E. LEHMANN and F. AICHELE " *Keimungsphysiologie der Graser (Granubeele)*" 1934.
2. THE Technique of Grass Seed Production at the Welsh Plant Breeding Station, *Herbage Publ. Bull.* 22. Imp. Bur. of Plant Genetics. Herb. Plants, Aberystwyth, Aug. 1937.
3. K. DORPH-PETERSEN " *Tidsskift for Planteavl,*" Vol. 38. p.p. 793-825, 1932.
4. T. W. FAGAN and H. TREFOR JONES. "The nutritive value of Grasses as shown by their Chemical Composition," *Welsh P.B.S. Bull.* No. 3, Series H. Seasons 1920-23.
5. S. F. ARMSTRONG, " British Grasses and their Employment in Agriculture, *Cambridge Univ. Press,* 3rd Ed. 1937.
6. W. S. IILJN " Precipitation of calcium by Plants on different habitats. *Bull. de L. Ass. Russe a Prague.* Vol. VCX. No. 27, 1937.
7. ALEXANDER LAUDER " The composition and Utilisation of Straws." *Scottish Jnl. of Agric.* Vol. 1., No. 3., July, 1918.

THE EFFECT OF PARTIAL FIELD-DRYING AND ARTIFICIAL DRYING ON THE CHEMICAL COMPOSITION OF GRASS.

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The investigation into the effect of partial field drying and artificial drying on the chemical composition of grass begun in 1937 was continued in 1938. The programme mapped out for the season, however, was rather disorganized by the long drought from which our pastures suffered in the early spring, the rainfall during the months of February to May inclusive being only 5.92 inches, compared with an average of 10.69 inches for the corresponding months of the last ten years. From April 5 to May 14 less than half an inch (0.41 inches) of rain fell, and this exceedingly dry period was accompanied by a series of hard frosts. Thus frost was recorded on seventeen days between April 4 and 30th, as well as on three days in early May.

The effect of this prolonged drought, accompanied as it was by frost, on the growth of our pastures generally will long be remembered, for it resulted in many farmers, owing to the scarcity of grass, having to resort once more to the winter feeding of stock. The combined effect of these weather conditions at this time of year is well illustrated in the moisture content of the herbage of a field kept for seed hay, as shown below :—

Date of cutting. 1938.	*Percentage of Moisture.*
April 11	77.7
,, 25	78.5
May 3	70.0
,, 10	64.5
,, 17	80.5
,, 31	78.0

The sample taken on May 10 shows the maximum effect, when the moisture content reached the low level of 64.5 per cent. The crop at this sampling had a flaccid appearance, the tips of the grasses and leaves of the clover being blackened. The drought ended on May 16, heavy rain falling through the night and continuing up to the time of sampling on the following day. This accounts for the large increase in moisture of the sample taken on that day. Towards the end of the month the moisture content of the herbage had become normal and the crop had regained a healthy appearance.

In a previous paper (1) the important bearing of partial field drying on the cost of production of dried grass was emphasized and it was felt that further study of the effect of wilting, under a variety of conditions, on the nutritive value of grass should be undertaken. For this purpose " Ardd Fawr," a field kept for seed hay at the College Farm, Nantcellan, was kindly placed at our disposal. The seeds mixture sown was Italian and perennial rye-grasses, with broad red and late-flowering red clovers, from which samples at approximately weekly intervals were taken from April 11 to the time it was cut as hay on June 9, 1938. When the sample was cut the grasses and clovers making up the herbage were mixed as intimately as possible and the produce of the cutting divided into four parts : one part was subjected to chemical examination as soon as possible after cutting, and the remaining three after forty-eight hours' wilting under the following conditions :—

(a) on the field in the open
(b) under cover of galvanized iron raised a few feet from the ground
(c) in a jute scrim bag suspended from a beam in a Dutch barn

The dry matter, protein and carotene (2) were determined in each of the four samples, and the results of this examination is given in Table I which shows the percentage of these constituents in the herbage as cut and after wilting under the conditions stated.

TABLE I.

Date when cut	*Treatment*	*Percentage dry matter*	*Calculated on dry matter*	
			Percentage crude protein	*Carotene in mgm. per 100 gm.*
25/4/38	As cut	21.5	20.0	38.7
	Wilting in field	53.5	17.8	22.6
	Wilting under cover	54.5	19.0	25.4
	Wilting in scrim bag	63.0	19.6	25.7
3/5/38	As cut	30.0	15.6	32.3
	Wilting in field	64.0	16.3	27.3
	Wilting under cover	59.0	16.8	29.3
	Wilting in scrim bag	64.5	16.0	28.4
24/5/38	As cut	30.5	11.6	21.6
	Wilting in field	37.5	12.0	20.0
	Wilting under cover	41.0	12.2	19.0
	Wilting in scrim bag	52.0	12.1	18.7
31/5/38	As cut	22.0	10.4	21.8
	Wilting in field	22.0	11.4	16.8
	Wilting under cover	33.0	10.0	16.0
	Wilting in scrim bag	53.0	10.8	16.3

The weather at the time of cutting, and during the wilting of the four samples, was as follows. During the period of wilting of the first and second samples no rain fell, and the herbage was exposed to 3.6 and 15.6 hours of sunshine respectively. The third sample while wilting was exposed to 0.33 inches of rain and 8 hours of sunshine, and the fourth sample to 0.42 inches of rain, but only 0.8 hours of sunshine.

The influence of these weather conditions on the loss of water is seen when the percentage of dry matter in the samples after wilting in the field is compared with that of the corresponding sample as cut. For example, on comparing samples one and two, with sample four, over 40 per cent of the original water content of the former was lost in wilting, whereas the latter, owing to the unfavourable weather, lost none. If, on the other hand, the weather is favourable, wilting in the field is shown to be as effective as under cover or in scrim bags. The advantage of some form of protection from unfavourable weather during wilting is seen in sample four, where in the field the herbage lost no water, but under cover, or in scrim bags, it lost 14 and 40 per cent respectively of the oringinal water content.

The variation of the protein in the dry matter of the samples as cut and wilted under different conditions is probably not of great significance, apart from the fact that it reveals sampling errors, which, with bulky material made up of a mixture of grasses and clovers, are extremely difficult to overcome.

The loss of carotene is on the whole greater when the herbage is allowed to wilt in the open than when wilting takes place under cover or in scrim bags. The two latter methods appear to be equally effective as methods of protection against the loss of carotene.

The above results are almost wholly in agreement with those of season 1937, and go to show that wilting in the field has little effect on the percentage of protein in the dry matter of the herbage.

The effect of exposure to weather on the carotene content of the herbage does not appear to be as pronounced as in the preceding season. In this connexion, however, it has to be remembered that the type of herbage dealt with in the two seasons is not strictly comparable. In 1937 it was comparatively young grass, whereas the present series of samples represent herbage that is progressively becoming more mature. There is also some evidence to show that the carotene in young, compared with more mature herbage is more susceptible to loss under these conditions.

As wilting in the field is likely to remain the general practice until some cheap method that affords protection is devised and facilities for the circulation of air through the herbage are forth-coming, the effect of forty-eight hours' wilting in the field on the percentage of dry matter, protein and carotene of all the cuts taken is given in Table II.

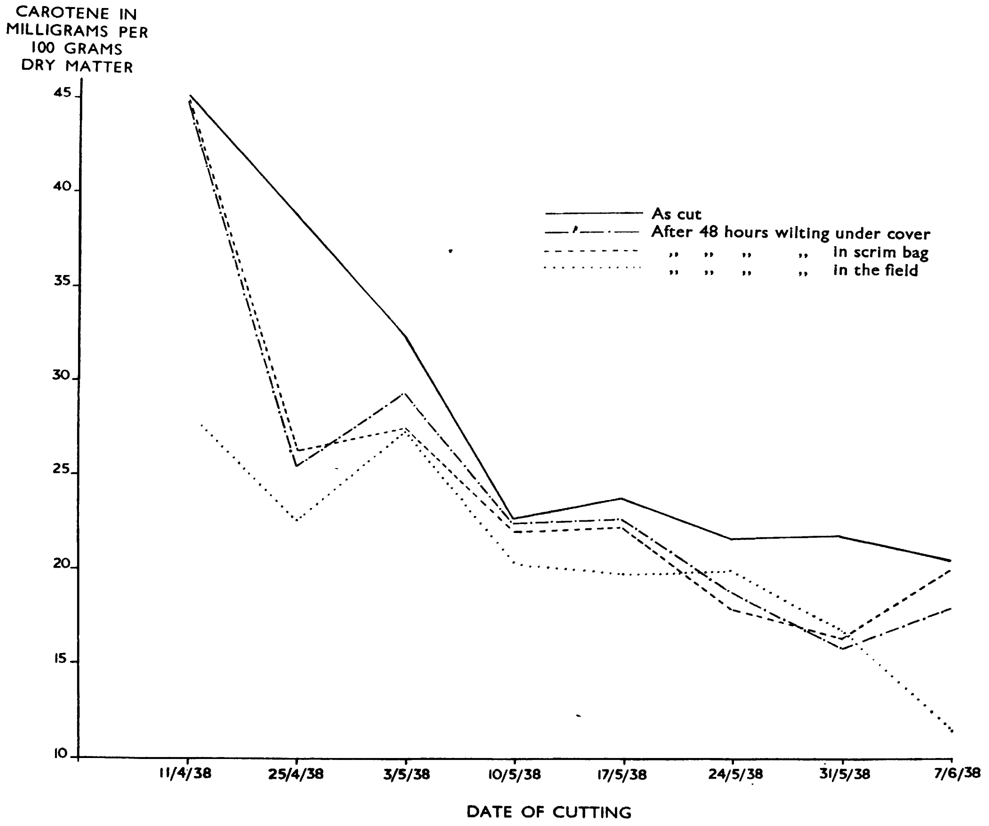
TABLE II.

					Calculated on dry matter	
Date of cutting	*Wilting*	*Rainfall in inches during wilting*	*Hours of sunshine*	*Percentage of dry matter*	*Percentage of crude protein*	*Mgm. of carotene per* 100 *gm.*
11/4/38	None	Nil	21.2	22.3	23.3	45.0
,,	48 hours			38.5	23.0	28.4
25/4/38	None	Nil	3.6	21.5	20.0	38.7
,,	48 hours			53.5	17.8	22.6
3/5/38	None	Nil	15.6	30.0	16.0	32.3
,,	48 hours			64.0	15.7	27.3
10/5/38	None	Nil	7.0	35.5	14.4	22.7
,,	48 hours			63.0	14.9	20.4
17/5/38	None	Trace	2.6	19.5	14.2	23.8
,,	48 hours			49.0	15.0	19.8
24/5/38	None	0.33	8.0	30.5	11.6	21.6
,,	48 hours			37.5	12.0	18.0
31/5/38	None	0.42	0.8	22.0	10.4	21.8
	48 hours			22.0	11.4	16.8
7/6/38	None	0.24	15.5	25.0	10.0	20.6
,,	48 hours			38.0	9.7	11.5
9/6/38	None	0.07	14.3	29.0	10.9	21.8
,,	48 hours			54.0	11.4	15.9
,,	4 days	0.25	25.6	56.0	11.0	12.6
,,	6 days	0.25	41.4	67.0	11.4	5.1
16/6/38	As harvested	0.25	49.0	87.3	10.6	4.9

From the percentage of dry matter the loss of moisture after forty-eight hours' wilting is found to vary within wide limits, and, as already mentioned, is largely dependent upon the weather conditions prevailing at the time. At one extreme no loss has taken place, while at the other the loss is approximately 50 per cent of that originally present in the herbage. The reason for the sudden fall in the percentage of dry matter of the sample cut on May 17 has been referred to earlier, and is accounted for by the fact that the herbage when cut and sampled was extremely wet.

The difference in protein content between the dry matter of the wilted and unwilted samples is, as previously suggested, probably due to errors in sampling, though the high percentage of samples in which this is higher in the wilted may be due to other reasons, such as loss of other constituents in the process.

FIG. 1.—Variation in carotene content of grass samples from Ardd Fawr Field from 11/4/38 to 7/6/38.



The advancing maturity of the herbage is accompanied by a gradual fall in the percentage of protein, a characteristic change of all grasses and clovers with age.

The loss of carotene is found to be greater in those samples which were originally rich in this constituent, with the result that the carotene content of the wilted samples tends to be more constant than that of the samples as cut. The greatest loss of carotene, however, is seen to have taken place in the sample cut on June 7, which was exposed to approximately one-quarter of an inch of rain and twenty hours of sunshine while wilting. This is in agreement with the results obtained in 1937, when exposure to a combination of rain and sunshine was found to result in a greater loss of carotene. The average loss of this constituent after wilting for forty-eight hours in the field was 26.3 per cent, whereas in wilting under cover, or in jute scrim bags the loss was 13 and 11 per cent respectively, only half as much carotene being lost when wilting takes place under cover as when this takes place in the field.

The series of samples taken between June 9 and 16 were those of the crop as cut for hay, after wilting for varying periods, and when harvested. The harvesting of hay in 1938 was extremely difficult, the interval between the cutting and harvesting of this particular crop being seven days, an interval which was short compared with that experienced by many others. As shown in Table II, in the interval between cutting and carrying the crop was exposed to over-one-quarter of an inch of rain and to approximately fifty hours of sunshine. The effect of these conditions on the protein content of the crop is small, but the carotene has suffered a fall from 21.8 to 4.9 mgm. per 100 gm. dry matter.

The curves in Fig. 1 illustrate the variation in carotene of each sample of the herbage at different stages of growth up to the time of cutting as hay and after wilting under the conditions indicated.

The chief points of interest illustrated by the graphs are (1) the rapid fall of carotene in the successive samples of freshly-cut herbage up to the second week in May, compared with the fairly constant carotene content of the subsequent weekly cuts ; (2) the more gradual fall in carotene over the whole period of the samples wilted in the open field, and the similarity of the carotene content of the samples wilted under cover and in jute scrim bags, and (3) the sudden increase of carotene in all the wilted samples cut on May 3. This is difficult to understand, for the weather was dry and sunny, as was the case when the previous samples were wilting.

In 1937 it was found that some leaching of certain mineral constituents took place when herbage that had partly wilted was exposed to rain. The results in 1938 show similar tendencies, as indicated in Table III.

TABLE III.

Date of cutting	*Wilting*	*Silica-free-ash*	P_2O_5	*CaO*	K_2O	*Cl.*
11/4/38	None	9.88	1.05	1.36	4.20	1.49
,,	48 hours	9.62	1.04	1.45	3.65	1.31
25/4/38	None	8.89	1.07	1.49	3.47	1.15
,,	48 hours	8.84	0.85	1.49	4.00	1.08
3/5/38	None	7.97	0.77	1.26	3.78	1.11
,,	48 hours	8.48	0.79	1.20	3.76	1.04
10/5/38	None	7.86	0.73	1.30	3.47	1.11
,,	48 hours	7.82	0.72	1.39	3.39	1.06
17/5/38	None	7.27	0.73	1.27	2.76	1.10
,,	48 hours	7.06	0.65	1.39	2.94	0.93
24/5/38	None	6.37	0.65	1.30	2.48	0.93
,,	48 hours	6.00	0.59	1.40	1.60	0.90
31/5/38	None	5.55	0.56	1.13	2.20	0.93
,,	48 hours	5.61	0.55	1.46	1.69	0.95
7/6/38	None	5.90	0.58	1.38	1.86	0.87
,,	48 hours	5.61	0.57	1.38	1.33	0.96
9/6/38	None	5.64	0.59	1.29	2.15	0.95
,,	48 hours	5.87	0.60	1.28	2.07	1.00
,,	7 days	5.28	0.61	0.74	1.97	1.07

When the percentage of the different constituents determined in the dry matter of each sample as cut is compared with that present in the same sample after wilting for forty-eight hours in the field potash appears to be the most liable to leaching by rain. An indication of the weather conditions during each wilting period of the different samples may be obtained from Table II. From this it is seen that the first four cuts were made when the weather was dry, with varying amounts of sunshine. Although the first cut shows some loss of potash and chlorine, this may be due to the succulent character of the herbage at this period, for the succeeding cuts taken during the dry period give little evidence of loss of any mineral constituents during wilting. It has also to be remembered that it was after the second cut was taken that the effect of the drought and frost became evident on the crop, so that there was a possibility for the easily lost constituents to have been lost before the sample was actually cut. From the middle of May onwards the weather was wet, when a considerable loss of potash took place, but over a period of forty-eight hours' wilting there is little evidence of the loss of any other mineral constituent.

The crop, as already mentioned, was cut for hay on June 9, and harvested on June 16. The weather conditions during this period are shown in Table II. In this sample the loss of lime appears to be the outstanding feature, but although the greatest care was exercised in the making of the hay, it had been put up in cocks and subsequently spread. This, in a crop of this nature, is always attended by the risk that the finer parts of the herbage, for example, the leaves of clover may be lost, which would account to a large extent for the fall in lime in the crop as harvested.

The results so far discussed relate to the cutting, wilting and sampling of the herbage under experimental conditions, whereas those that follow relate to samples of dried grass produced under practical conditions on a commercial scale. These samples were all taken by, or under the supervision of, a responsible person, and were placed in airtight tins and despatched to the laboratory the day they were taken.

Frequent reference has been made to the effect of the drought on the character of the growth of the early spring grass, for not only did this affect the moisture content of the herbage, but it had an adverse effect on its protein content also.

It is generally recognized that the first cuts representing the young spring growth taken from pasture set aside for systematic cutting and drying provide the product richest in protein. In 1938, however, the first cuts taken in our area were the poorest of all in this constituent. The effects of the drought were twofold, there was a check in the growth of the herbage, and at the same time the growth that took place tended to produce a stemmy rather than a leafy product. This difference in protein content between the first and subsequent samples of commercially dried grass, from four representative pastures in the area, is illustrated in Table IV.

TABLE IV.

Field		*First cut*	*Second cut*	*Third cut*	*Fourth cut*
A	Date of cutting	25/5/38	23/6/38	4/7/38	—
	Percentage crude protein	11.96	16.91	18.00	—
B	Date of cutting	23/5/38	21/6/38	22/7/38	6/9/38
	Percentage crude protein	13.05	17.32	19.82	14.25
C	Date of cutting	30/5/38	14/6/38	11/7/38	—
	Percentage crude protein	13.42	18.28	15.30	—
D	Date of cutting	6/5/38	21/7/38	5/9/38	—
	Percentage crude protein	13.35	18.27	14.20	—

Field A was an old pasture, while Fields B, C and D were second year leys. The results show that when normal climatic conditions once more prevailed, the pastures quickly recovered, with the result that the product of the second cuts from each of these fields showed a considerable increase in protein content over the first, and that no subsequent cut from any of these fields contained as low a protein content as the first.

The bulk of the samples of dried grass were obtained from three centres, at two a Kaloroil drier was employed and a Billingham drier at the third.

The results given in Table V illustrate the effect of short periods of wilting as practised in the production of dried grass under practical conditions at all three centres.

TABLE V.

					In dry matter		
						Mgm. carotene in 100 gm. in	
Date of cutting	*Period of wilting in hours*	*Rainfall in inches*	*Sun-shine in hours*	*Per-centage of dry matter*	*Per-centage of crude protein*	*Freshly cut grass*	*Dried grass*
1938							
June 8	0	Nil	17.1	24.0	13.1	31.2	19.2
„ 8	12			27.0	13.0	27.8	19.8
„ 9	36			35.0	13.5	26.0	18.2
„ 15	0	0.03	33.0	29.0	12.8	26.0	18.0
„ 16	24			38.0	12.9	22.7	18.2
„ 18	72			44.0	13.4	19.6	16.4
July 26	0	0.45	16.4	18.5	14.9	28.8	18.9
„ 29	72			19.5	15.2	20.0	12.0
Aug. 3	0	0.15	7.6	21.7	15.4	32.2	23.3
„ 4	24			33.5	15.2	26.4	13.0
June 29	0	0.08	15.9	26.0	18.6	33.2	23.1
„ 30	24			50.0	17.5	24.0	22.4
July 26	0	0.24	8.7	33.0	18.9	28.3	18.7
„ 27	24			42.0	19.0	20.2	18.1
Aug. 11	0	0.01	7.2	14.3	17.7	44.8	21.3
„ 13	48			33.5	16.8	26.5	19.5

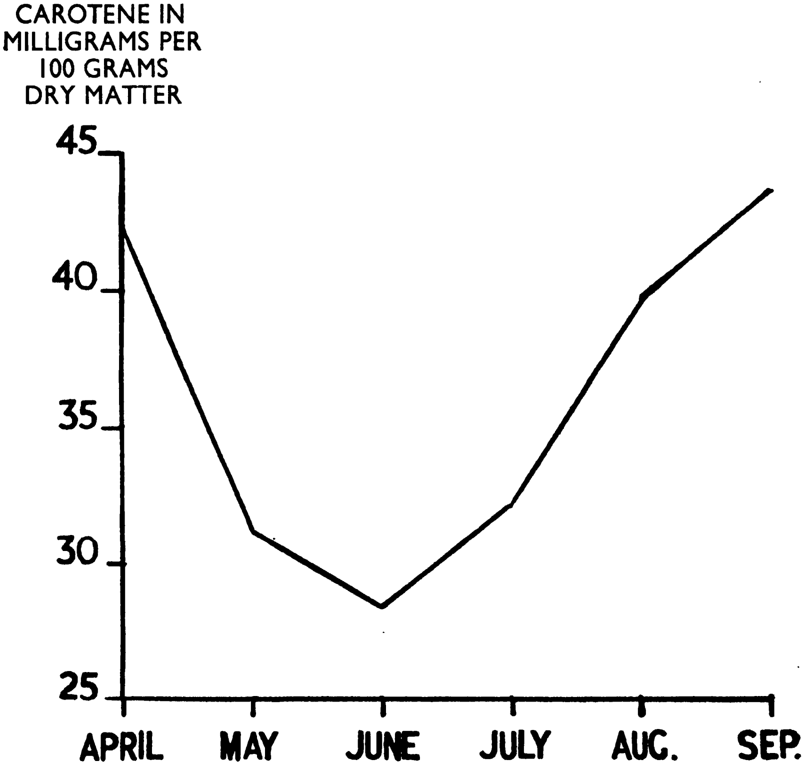
The first four samples were obtained from farms where Kaloroil driers were employed, and the last three where a Billingham drier was used.

From the results shown in Table V, season 1938 would appear to be a very unsatisfactory one from the grass drier's point of view, for unless the weather was exceedingly favourable, the reduction in cost of drying the grass as a result of allowing it to wilt was very small. The one exception in the table is the sample cut on June 29, which in twenty-four hours lost approximately 33 per cent of the original water that it contained as a result of wilting. The remainder show a loss of only 1 to 21 per cent for periods ranging from 12 to 72 hours.

The loss of protein as a result of wilting is, as was the case in the seeds hay, small. Similarly the loss in carotene is in agreement with the previous findings, and the tendency of the carotene content in the majority of the samples of dried grass to be constant, irrespective of what it was in the sample before drying, is in agreement with the results of season 1937.

During the season a large number of samples of freshly-cut grass intended for drying arrived in the laboratory, and among other constituents determined in these samples was their carotene content. The curve in Fig. 2 shows the average carotene content of all these samples cut in the same month, and illustrates the seasonal variation in this constitutent during the growing season.

FIG. 2.—Graph showing the seasonal variation in the carotene content of fresh herbage for the year 1938.



It should be pointed out that the samples were received from a number of sources and were consequently of mixed origin. However, they all had this in common, that they were representative samples of fresh herbage cut for the production of dried grass.

From Fig 2. the average carotene content of these samples in April is seen to be high, but in May it had fallen to almost half of that in April, followed by a still further fall in June. A steady increase, however, takes place in July, August and September, so that in the last month the average carotene content of these samples is again similar to what it was in April.

The general resemblance of the graph to that representing the protein content of grass cut at stated intervals throughout the growing season is quite striking. This is in agreement with the results of the previous season, when a fairly close correlation was found to exist between the protein and carotene content of freshly-cut grass.

Throughout the season samples of dried grass were received in the laboratory for protein determination. These were sent by grass driers, and the result of their examination is of interest in that they give a fair indication of the quality of dried grass produced in our area in season 1938. Sixty-four of these samples were examined, and in Table VI they are classified on the basis of their protein content

TABLE VI.

Percentage of crude protein	*Number of samples*	*Expressed as percentage of total*
18 or over	7	11
15 to 18	14	22
12 to 15	33	52
Under 12	10	15

Reference to the table shows that of the sixty-four samples examined only seven contained over 18 per cent of protein, the highest and lowest protein contents found being 19.8 and 9.3 per cent respectively. Compared with the correposnding samples examined in season 1937 (1) the above results show a higher percentage of the total samples received to contain from 12 to 15 per cent, and a lower percentage with from 15 to 18 per cent, that is, judged by these results there were more samples of medium quality dried grass and super hay produced in our area in 1938 than in 1937.

It should be pointed out that the above classification is based on the percentage of crude protein in the dry matter, and a less favourable result would be obtained if this had been expressed on the dried grass as received in the laboratory, since these samples contained from 5 to 9 per cent of moisture.

Summary.

The paper is a continuation of the investigation begun in 1937 into the influence of wilting under different conditions, and of the artificial drying of grass on its chemical composition.

Although seasons 1937 and 1938 differed considerably from one another, the results obtained in the two seasons are in general agreement. It was found in both seasons that wilting in the field under favourable climatic conditions can effect appreciable reductions in the cost of drying, for under such conditions grass lost 30 and 50 per cent of its original water content after forty-eight hours' wilting. Should the weather, on the other hand, be unfavourable, this may result in very little or no loss of water.

Wilting in the field or under cover appears to have little effect on the percentage of protein present in the dry matter.

Larger amounts of carotene are lost when wilting takes place in the field than under cover or in jute scrim bags. Thus the average loss of carotene after wilting for forty-eight hours in the field was 26 per cent, whereas when wilting took place under cover, or in jute scrim bags, the loss was 13 and 11 per cent respectively. In both seasons the most serious loss of carotene occurred when the herbage was exposed to rain and sunshine. The 1938 results suggest that the loss of carotene is greater in those samples which are originally rich in this constituent.

Of the mineral constituents determined, potash appears to be the most liable to loss when herbage wilts under unfavourable conditions.

Our thanks are due to Professor Sir R. George Stapledon, C.B.E., M.A., F.R.S., and his staff; to Stanley M. Bligh, Esq., B.A., of Cilmery Park, Builth Wells, Professor J. J. Griffith, B.Sc., and Mr. Richard Phillips, M.Sc., for the facilities they provided in the taking of the samples and in the carrying out of this work.

References.

1. Fagan, T. W. and Ashton, W. M. (1938). The effect of partial field drying and artificial drying on the chemical composition of grass. *Welsh J. Agric.* Vol. XIV.
2. Ferguson, W. S. and Bishop, G. (1936). The estimation of carotene in agricultural products. *Analyst.* 61. 515-18.

SOIL SURVEY OF WALES.
PROGRESS REPORT, 1935-8.
SOUTH CAERNARVONSHIRE.

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Area Surveyed.

The area surveyed is a peninsular region of approximately 150 square miles, and comprises Lleyn and the greater part of Eivionydd. The northern limit is roughly a line extending from the southern slopes of Yr Eifl to Dolbenmaen, and thence southward to the coast about two miles east of Criccieth.

Topography.

The altitude range of the cultivable land is approximately from 400 ft. to sea level, though the major part of this is coastal lowland. Upland areas are of limited extent and the highest reaches, chiefly Garn Fadryn (1200 ft.), Mynydd Rhiw (960 ft.), and Garn Bodvean (900 ft.), are conspicuous features of the landscape. The eastern half of the area is a lowlying drift plain and the outline is generally undulating with occasional rolling slopes in the neighbourhood of the higher rocky features. A prevalent type of contour consists of low elongated drift ridges intermingled with wet flats. In such areas the surface relief is a useful guide in delimiting soil boundaries. In the west there is generally more evidence of the underlying rock. Garn Fadryn and Mynydd Rhiw are salient features, and there are numerous lesser rocky features particularly along the south-west coast. Where deep drift dominates, the outline is rolling with moderate slope. Where the glacial deposits are shallow or the country rock easily eroded, there is more diversity of outline. This is seen in the neighbourhood between Llaniestyn and Nanhoron where deep narrow valleys formed in the soft shale are a striking feature.

Climate.

The maritime character of the climate will be inferred from the fact that the area has about fifty miles of coastline and none of the land lies more than four miles from the sea. Whilst, in general, the winters are mild and the summers cool, seasonal conditions may be influenced by peculiarities of the topography. The aspect of certain localities is an important factor affecting plant growth. An instance of this was observed during the progress of the present survey. The rolling country lying north of Mynydd Cefn Amwlch and Garn Fadryn has open northerly to easterly aspects and during periods of easterly winds, which are commonly experienced during the late spring months, growth is liable to serious check. Spring corn was backward and the pastures remained bare. Most of the area, however, has a favourable aspect to south or south-west.

The total annual rainfall ranges according to the surface relief from about 30 inches on the more open lowland to 50 inches in the vicinity of the hills. Most of the district receives about 40 inches of rainfall annually.

A noteworthy feature is the frequent occurrence of dense sea-fog, which is prevalent over the western part of the peninsula during the early summer months. The beneficial effect of these fogs, by conserving soil moisture if not actually in adding to it, an effect noticeable particularly in the condition of the pastures, was strikingly apparent, when comparison was made during the same period with similarly situated pastures in other districts of equal rainfall.

Drainage.

The natural drainage of the area is served mainly by numerous small streams of local origin. In the west, the only water course of note is the River Soch, which has a winding course lying for the greater part of its length through the lowland adjoining Porth Neigwl. The catchment area is small and the spate periods are of periodic occurrence. A considerable area adjoining the river and extending far inland has very little elevation, and prolonged rainfall usually results in flooding. This is liable to occur as far inland as Sarn. The area of alluvial flat associated with the river is small and of low value owing to the permanently high water table.

In the Eifionydd area the main drainage outlets are the rivers Erch and, farther east, the Dwyfawr and Dwyfach. These rivers lie along narrow drift valleys which are often deeply cut, and boulder-strewn. River alluvium is confined to narrow strips and is generally of little importance. The only noteworthy area of alluvium in this part of the area is the flat adjoining Dolbenmaen, though the agricultural value of this is greatly diminished owing to poor drainage. The water table is permanently high and there are deep accumulations of peat.

Akin to the river courses are the more extensive lacustrine flats which together occupy an area of approximately 1,000 acres. These flats receive the drainage waters from a wide area of surrounding country and owing to poor outlet facilities they are normally waterlogged. This stagnant condition is reflected in the fen-like character of the peat.

Along the coast between Penrhos and Criccieth there are extensive areas of waterlogged flats of marine origin. Lack of drainage facilities appears to be accentuated by the development of wind-borne sand-banks, which generally enclose the flats.

Geology.

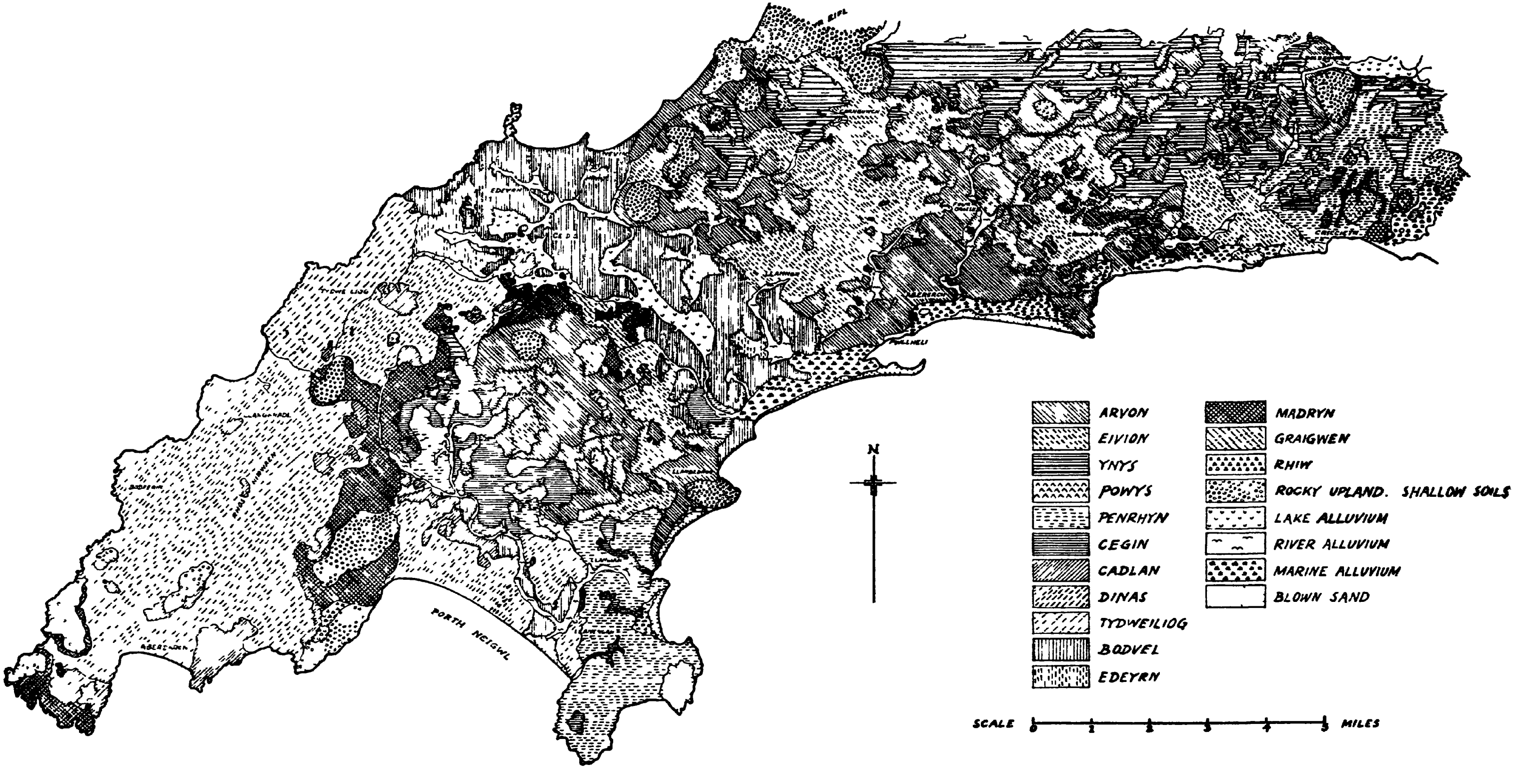
The rocks underlying the greater part of the area consist of dark shales belonging to the Ordovician System. The shale area coincides generally with lower lying country of smooth contour. The higher features, which have more rugged outline, are formed mainly of massive igneous rocks of rhyolitic character. In addition to these acidic rocks there are occasional outcrops of quartz dolerite which is of basic character. Only in one locality, however, near Rhiw do we find a mappable area of soils derived from this material. This occurs in pockets on the scree slopes of the rugged headland which is predominantly rocky.

Along the north-west coast the underlying rock consists of group of metamorphic gneisses and schists belonging to the Mona Complex, but owing to the presence of deep glacial drift, the country rock has no appreciable influence on the soils of the area.

With regard to the geological derivation of the glacial deposits of the district, three classes of drift have been recognised. Over most of the eastern part of the area the drift is generally of a stony character derived principally from hard acidic rocks similar to the igneous rocks and coarse grits which outcrop in the area. There are also drifts derived almost entirely from the soft shales and associated fine-ground grits. These are easily recognized. A third group consists of boulder clay and glacial sand and gravel foreign to the area and referred to later in this report as northern drift. From the appearance of this drift and certain other characteristics, particularly its content of detrital calcium carbonate, it is probably derived from rocks belonging to the Carboniferous System.

Related to the calcareous boulder clay, which is the dominant material in the extreme west, there are light sands and gravels which occupy a belt of country extending across the peninsula from Nevin to Penrhos. Small isolated areas of similar sandy drift occur also along the banks of the river Soch between Llandegwning and Llanengan. This sandy drift is non-calcareous.

In addition to these main groups of drift, there are areas where the drift is of a mixed composition owing to the local diversity of the country rock and peculiarities of surface relief.



SOIL SERIES MAP OF LLEYN PENINSULA.

Soil Series.

The principles underlying the Soil Survey have already been set forth in earlier reports. Briefly, the underlying consideration is that the character of the soil is determined by the nature of the parent material and also by the conditions of formation. According to the method of classification now adopted, soils are grouped into series, each series consisting of a group of soils derived from the same or similar parent material under the same conditions of formation and showing a general similarity of profile in vertical section.

The following series have been mapped in South Caernarvonshire. They may be conveniently grouped into suites according to the geological material from which they are derived.

I. Named Series.

Soils derived from Ordovician shale material.

Powys Series.
Penrhyn Series.
Cegin Series.

Soils derived from acidic igneous and coarse crystalline grit material.

Arvon Series.*
Eivion Series
Ynys Series.

Soils derived from basic igneous rock material.

Rhiw Series.

Soils derived from Carboniferous material.

(a) From heavy boulder clay.
Cadlan Series.
Dinas Series.
Tydweiliog Series.

(b) From sands and gravels.
Bodvel Series.
Edeyrn Series.

Drifts of mixed geological origin.

Madryn Series (Carboniferous with acidic igneous and shale material.)
Graigwen Series.

**Foot Note.*—The soil series derived from these materials have been regrouped and re-named. The Arfon Series includes the former Ebenezer and Gaerwen Series, the Eivion Series includes the former Sion and Gesail Series, whilst the Ynys Series includes the former Bethel and Braint Series.

II. Unclassified Soils.

Shallow upland soils.
River alluvium
Lake alluvium.
Marine alluvium.
Wind-borne sand.

Soils derived from Ordovician Shale material.

Powys Series.

The soils of this series are formed in *situ* from the underlying rock, but owing to the prevalence of glacial or colluvial drift they occupy only a small area. The only noteworthy area of Powys soil lies on the ridges of the hill ground which overlooks Criccieth. The most typical profile consists of about six inches of brown shaly loam overlying a bright orange-brown brashy subsoil on rock. Profile depth varies considerably according to the situation, and ranges from almost bare rock to the deeper phases which merge into colluvium. On these areas of sharp relief, the profile commonly shows evidence of soil erosion, and rusty-brown surface soils have been mapped. The Powys Soils generally are liable to seasonal drought. Table I (at end) contains the analytical data of a Powys profile sampled at Penystymllyn, near Criccieth. The high content of organic matter and the low lime and phosphate status are characteristic of these shallow upland soils. The differentiation seen in the composition of the clay fraction of the soil horizons is also a feature reflecting the leached condition of these soils. They are generally under old pastures of rather inferior quality with bentgrass predominant.

Penrhyn Series.

The soils of this series are soils formed on shaly drift. Soil depth varies according to the depth and texture of the drift. The deeper Penrhyn soils are among the best in the district. They occur interspersed with poorly drained shale soils over an area which extends from Llaniestyn to the Mynydd Cilan headland and embraces Botwnnog and Llangian. In places the surface relief is sharply undulating and the soils on the higher-lying features are affected by seasonal drought.

The analytical data of a Penrhyn profile are given in Table II. This sample, taken from a sharply rolling slope south of Mynytho, represents the soils formed on the shallower drift. The exchangeable lime content is low and this is a fairly general condition of all the shale soils. The phosphate status varies considerably and is mostly low. These soils appear to give good response to phosphatic dressings, particularly basic slag.

The Penrhyn soils are mostly under grass of medium to poor quality. On the steeper slopes the cover consists largely of bracken and gorse.

Cegin Series.

Associated with the Penrhyn series are soils of similar parent material but developed under poor drainage conditions. The impedance of the drainage is due in places to the depressed situation and absence of slope, but more generally it is due to the impervious texture of the subsoil. The degree of impedance varies and whilst the better types approach in appearance and cropping capacity to the well-drained soils, the wettest types are poor wet heaths of low value. In South Caernarvonshire the Cegin Series are of the better class and under proper management are fairly productive.

Table III contains the analytical data for a typical soil profile of the Cegin Series. This is a heavy profile with drainage impedance due mainly to the stiff nature of soil mass. The figures show a slight deficiency of exchangeable lime and a low phosphate status, and are representative of most of the Cegin soils of this area.

Soils derived from acid or intermediate igneous material.

Soils of this origin together occupy approximately one half of the total area surveyed, and comprise freely drained and poorly drained series, and these are largely intermingled in distribution.

Arvon Series.

The freely drained soils belong to the Arvon Series. They are essentially stony light loams, mostly of satisfactory depth and the profile generally shows an increasing content of stones with increasing depth. The soil horizons are as a rule well developed, and reflect the free drainage conditions. The typical profile consists of warm brown or slightly reddish-brown top soil varying in depth from nine to eighteen inches, bright yellowish to reddish brown subsoil, and greyish yellowish-brown base material which is the comparatively unaltered parent drift.

The deeper phases of this series situated in sheltered localities appear to be well suited for market gardening. They are free working soils and respond well to good treatment.

The analytical data of representative Arvon soils are given in Tables VI, VII and VIII. They are naturally poor in lime, and many of these soils have long since reached a very low level of fertility. The phosphate and potash content also fairly generally too low for satisfactory growth. These light soils are not suited for permanent pastures, and more frequent arable breaks would lead to more and better stock keep.

Eivion Series.

These soils are similar in origin to the Arvon Series, but they differ in character owing to their development under conditions of impeded drainage. They mostly occupy gently rolling slopes and the lowlying flat areas which intermingle with the areas of free drainage.

The profile consists of dark grey-brown medium to heavy loam with variable content of organic matter, often with a thin peaty surface layer, over paler greyish or yellowish-brown stiff subsoil. The deeper material is commonly a stiff bluish-grey heavy silt. Table IX gives the analytical data of a fairly typical Eivion soil profile sampled from an area of wet heavy boulder clay carrying rushy pasture near Llannor. The figures indicate a very low lime status and also deficiency of available phosphoric acid and potash, and these represent the condition throughout most of these soils.

Ynys Series.

Along the north east of the area on the more elevated rolling slopes there are extensive tracts of wet rushy land of moorland character and of very low agricultural value. The underlying drift is essentially similar to that which, with better drainage or management, produces the more useful soils found in that part of the district. But poor drainage and lack of attention through generations has resulted in the development of an extremely derelict condition. Wet peat varying from a few inches to great depth is the dominant feature and the conditions grow steadily worse.

Table X shows the analytical data of a typical Ynys profile. The surface layer, to a depth of about twelve inches, consists of dark brown peat which is slimy in the lower half of its depth. Below this is grey-brown peaty sludge, in which the mineral material is mainly bleached. The organic matter content diminishes sharply in the lower layers and at approximately thirty inches the material is raw bluish-grey silt loam. Regarding the plant nutrient status of these derelict soils, it is to be expected that they show general impoverishment. The reclamation of some of this land is a matter deserving of consideration. Clearly the first step must be towards improvement of the moisture conditions, and as a good deal of these wet areas have favourable gradients, this could be achieved by the ordinary field methods. Subsequent addition of lime and other essential plant food elements would bring the land into cropping condition. Reclamation by introduction of drains and subsequent liberal liming has been accomplished in certain localities.

Table XI contains the analytical data pertaining to an area which was reclaimed from wet peat some sixty years ago. This is now a mellow, free working soil of fair depth which compares favourably with the average soils of the district and may excel for the production of particular crops, such as oats and potatoes.

Soils derived from basic igneous material.

Rhiw Series.

A very limited area confined to the scree slopes of a rocky coastal headland adjoining Mynydd Rhiw is occupied by soils derived from basic quartz dolerite. Although these soils make but little contribution to the agricultural resources of the district, they are of particular interest owing to the rare occurrence in North Wales of soils derived from this rock type. The parent rock is characterized by the high content of basic constituents, and this character is reflected in the soil profile which is derived from it. These soils are formed mainly in pockets on the boulder strewn slopes, and they have obviously been in their present natural state for a great number of years. In spite of this, the soil profile with its strong colour throughout, shows little evidence of podsolization, and the herbage consists of fine palatable species, notably wild white clover and suckling clover. Soils derived from non-basic parent material under similar conditions as seen in various localities throughout the district show marked podsol character.

Table V shows the analytical data of the Rhiw Series. The organic matter content of the upper layers of the profile is high though this is mostly well incorporated with the mineral material. The figures indicate a remarkably good plant food status when allowance is made for the complete absence of treatment. The composition of the clay fraction indicates that the samples taken represent only the upper layers of the pedological profile. The raw brash material from which the profile has developed lies at a considerably greater depth.

Soils derived from fine-textured Carboniferous drift.

Dinas Series.

The Northern Drift has produced three series of soils, the most important of which, both in extent and in potential agricultural value, is the Dinas Series. The parent material of these soils is fairly generally a stiff brownish-grey clay with a high content of calcium carbonate. The analytical data of a typical profile sampled in the neighbourhood of Rhos Hirwaen are contained in Table XII. In the development of the soil profile on this boulder clay, the calcium carbonate is completely removed by leaching, and not infrequently there is a marked degree of acidity in the surface soil particularly in areas where, owing to neglect, the vegetation has reverted to rank rhos conditions. The drainage conditions are variable and in the main poor. In this connexion reference may be made to the beneficial effect of prolonged summer drought on the drainage conditions in some of these deep stoneless clays. The cracks which are commonly seen in the surface extend to a depth three or four feet in abnormally dry seasons and the lasting benefit which this has upon the moisture conditions has been met with commonly during the progress of the Survey. Whilst these soils throughout are affected by the poor condition of the drainage and large tracts on rolling slopes are actually derelict wastes, the natural conditions in most of the area offer good facilities for improvement by ordinary drainage methods. The contour is favourable and large portions might be greatly improved by mole draining.

A noteworthy feature observed throughout the area occupied by this Northern boulder clay is the superior personnel of the hedge-bank flora. Cocksfoot and other species which thrive only on soil of fairly good nutrient status grows luxuriantly, and would appear to be an indication of the inherent good quality of these soils.

In mapping the soils of the Dinas Series, distinction has been drawn between badly impeded soils, most of which are uncultivated and carry rough natural vegetation, and those with less serious impedance which, with good management, can be maintained in fairly satisfactory condition.

Cadlan Series.

These are soils formed on the lighter phases of the Northern drift, and they are fairly free working soils of good depth. The drainage is satisfactory excepting occasional impedance which is met with in the deeper subsoil. The lighter texture and better drainage is reflected in the complete absence of calcium carbonate throughout this soil profile.

Table XIII contains the analytical data and description of a representative Cadlan profile.

Tydweiliog Series.

The distinguishing characters of the soil profile of this series are the light sand top soil derived as a glacial wash and a stiff impervious subsoil. It may be regarded as a hybrid profile consisting of Bodvel soil overlying Dinas subsoil.

These soils occupy a lowlying coastal area of approximately 2,000 acres. There is wide variation in the depth of the sandy horizon, in places this may reach a depth of three feet, or the clay may lie within a few inches of the surface. In an average profile the clay lies sufficiently close to the surface to influence the moisture conditions and there is fairly general evidence of impeded drainage. In the deeper sandy types with moderate slope, the moisture conditions are very desirable and there are areas well adapted for intensive cropping. The poorest types are shallow sands on raw clay, and these occur on the barren heaths lying in open bleak situations adjoining the coast. They have a sparse cover of heath plants, mainly heather and rushes.

The analytical data is given in Table XIV. This refers to a Tydweiliog profile which exhibits the mean of the conditions already described.

Bodvel Series.

The Bodvel soils are essentially sandy light loams derived from Northern glacial sands and gravels. Variations within the Series are closely correlated with the texture. Tables XV and XVI together indicate the textural range in this series. In Table XV are the data for the lightest types ; with approximately 80 per cent of sand, they are little better than mere physical media for plant growth. They are generally situated on sharp features and the excessively free drainage renders them poor and unproductive, and liable to acute seasonal drought. These are the conditions ruling over large tracts, as for example, in the neighbourhood of Rhydyclafdy. The soils are too poor to cultivate, and they have long since become bracken wastes and infested with rabbits. On the flatter areas or in depressions where the moisture conditions are more favourable, these light soils are particularly good and might be utilized for intensive cropping.

Edeyrn Series.

The soils of this series, also derived from sandy glacial drift and developed under conditions of poor drainage, have affinities with the deeper sandy phases of the Tydweiliog, but whereas in the latter soils the drainage impedance is due to an impervious subsoil, the Edeyrn soils are wet due to a high water-table. The profile consists throughout of silty sand with a varying content of organic matter, with local development of shallow peat. The area occupied by the Edeyrn soils is almost entirely rough wet grazing.

Soils derived from mixed drift.

Madryn Series.

Although there is some admixture in most of the glacial drifts of the area, in general there is predominance of one of the constituent materials which characterizes the derived soil profile. For example, the Arvon and Eivion soils are derived from drift consisting principally of igneous material, but there is generally some admixture of shaly material, though insufficient to influence the essential character of the derived soil. However, mixed drifts are encountered in which the influence of the constituents is blended in the derived soil profile. In some localities in Lleyn the drift is derived partly from Northern material and partly from local igneous and shaly material, and the soils are sufficiently well defined to be regarded as a separate series which have been mapped as the Madryn Series. Table XVII gives the analytical data of a Madryn profile. These soils are well-drained light to medium loams of good depth, and generally fairly productive.

Graigwen Series.

These are similar in origin to the Madryn soils but distinguished by poor drainage and generally heavier texture. They are greyish silty loams occupying wet depressions.

Unclassified Soils.

Shallow Upland Soils.

The higher reaches of the rocky uplands, together with other rough areas too rocky or broken for cultivation have been grouped as areas of shallow soils. Conditions on these areas are very variable, ranging from bare rock pavement and rock scree to colluvium of ample depth, but owing to the diversity of distribution, no definition of boundaries was attempted. The most prevalent profile is a strongly podsolic type consisting of four to eight inches of dark highly organic soil with a bright brown shallow subsoil lying on rock. There is acute seasonal drought and the only vegetation that survives these conditions consists very largely of heather and gorse or fine grasses, whilst bracken is dominant on the deeper soils.

Alluvial Soils and Related Lacustrine Soils.

The soils of the area which have been derived from alluvial deposits together occupy only a relatively small area. They comprise soils formed respectively from river alluvium, lake alluvium and marine alluvium.

River Soils.

River alluvium forms a very small total area and as a class of soils in South Caernarvonshire, they are of little importance. They are mostly peaty, sandy silts overlying greyish silt and the drainage conditions are poor.

Lacustrine Alluvial Soils.

The areas shown on the soil map as Lake Alluvium are characterized by a high water-table and a peaty surface layer. The main area of lacustrine soils is Cors Geirch, a boggy flat of some 500 acres, with which may be included the low-lying flats to the north-west, between Ceidio and Edeyrn. This area as a whole presents a wide variety of profile types and accurate delimitation of these is possible only by a detailed local survey. Cors Geirch is almost entirely a bog area with a water-table at or near the surface. Peat occurs throughout the area, varying from a few inches to several feet. The mineral subsoil is generally deep pale bleached silty sand but in places where the peat is shallow and impedance is less acute, the ferruginous zone, often indurated, lies within two feet of the surface. The vegetation consists largely of rushes and reeds together with bog myrtle and other bog-land species. Samples of peat from various points on the flat mostly show a high base status. This fen character is indicated by the presence of such plants as common sedge. Whilst the nutrient status of these lacustrine soils is mainly good, their foremost need is the improvement of the drainage conditions. Some measure of control has been achieved by means of open ditches but absence of slope appears to be an insuperable bar to improvement. Similar fen-like conditions exist in the wet peaty flats between Edeyrn and Llandudwen, but the water level is lower and the organic matter is mostly incorporated with the mineral sediment. Fen peat of great depth occurs locally.

Marine Alluvial Soils.

The marine flats are found only along the south coast. They have an aggregate area of about 2,000 acres and most of this lies in the neighbourhood of Pwllheli. These flats are all dominated by a high water table. The profile varies considerably owing to textural changes and to the variable accumulation of organic matter.

The soils of Penrhos flat consist of peaty silt, overlying silty coarse sand and water-logging is extensive. East of Tan-y-bwlch the conditions show improvement and in places there are peaty sands with fairly good drainage producing fair grass.

The soils of Morfa Abererch comprise a wide range of textural and moisture types. The water table is mostly at or very near the surface, except for occasional patches on slightly elevated sand features. Texture ranges from the lightest sand to stiff clay-silt with varying accumulation of peat according to the moisture conditions. The poorest type consists of deep peaty silt with the water level permanently at the surface, and dominated by rushes and other rough growth. The drier sandy soils are under cultivation and appear to be useful soils.

Llyn Ystymllyn is a water-logged marine flat of little agricultural importance.

Wind-borne Sand.

With the exception of an area in the vicinity of Trwyn y Wylfa, lying to the south of Abererch, the blown sand occurs in the form of elongated narrow strips fronting the marine flats. From the soil survey point of view they are of no importance. At Trwyn yr Wylfa blown sand occupies an upland area of approximately 300 acres. Though the sand drift is fairly deep in places, the soils are precariously dependent upon rainfall. The plant food status is very low and most of the area is a derelict rabbit warren with bracken predominant.

Conclusions.

Reviewing the area as a whole, the most noteworthy feature is the high proportion of land with defective drainage. It is estimated that fully fifty per cent of the cultivable or potentially cultivable land shows evidence of impedance. Furthermore, the worst affected areas are inherently the best since many of the lighter stony soils are at best second rate and expensive to maintain in a fertile condition. Soils such as the Dinas and Eivion series are capable of carrying high quality pastures were they adequately drained and managed. This prevalence of poor drainage is the more deplorable in view of the fact that widespread improvement is easily practicable. It is to be hoped that some of these derelict tracts will receive concerted attention before long.

Secondly we would point out the widespread deficiency of lime which exists in the area. Many soils have reached a very low level of fertility primarily owing to this cause, and there are vast areas of soils which will need liming in the very near future if their status is to be maintained. It is estimated that over 90 per cent of the soils of Lleyn and Eifionydd are in need of lime.

Phosphate deficiency is also widespread and remedial dressings are immediately necessary over large areas.

Finally, with regard to the enormous losses caused by the deplorably high rabbit population throughout most of the area and particularly in Lleyn, the writers are firmly of the opinion that the high soil banks which form the field boundaries are very largely contributory to the evil conditions which exist. These earth banks which are generally from four to six feet high are ideal burrowing grounds for rabbits. In order to convey to the reader who is unacquainted with the area, an idea of the density of the rabbit population in an average year, we can quote the figures pertaining to one farm in Lleyn which is representative of a wide district. This farm is 110 acres and the number of rabbits trapped from September to March amounted to over 2000. All the land is cultivated and the entire rabbit population finds cover in the earth banks.

In the interests of production and of the appearance of the countryside, we urge the levelling down of these earth banks and their replacement by quickthorn hedges planted only slightly above the general land level.

TABLE I.

Soil Nos. 937-939. *County* : Caernarvonshire. Sheet XXXIV. S.W.
Locality : Pen-ystumllyn, Criccieth.
Geological Data : Ordovician Shale. *Series* : Powys.

ANALYSIS OF AIR-DRY 2mm. SAMPLE.

	S.937 *0–10″*	*S.938* *10–17″*	*S. 939* *17″+*
Coarse Sand	21.8	21.0	32.1
Fine Sand	19.9	22.5	24.6
Silt	25.8	23.8	28.3
Clay	22.8	24.0	14.0
Moisture	3.08	3.00	1.01
Calcium Carbonate	Nil	Nil	Nil

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Loss on ignition	11.44	7.86	4.98
Org. Carbon	4.38	1.78	0.52

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pH	5.18	5.49	6.28
Exch. CaO	0.125	0.128	0.053
Citric Sol. P_2O_5	0.0075		
,, ,, K_2O	0.0093		
Total P_2O_5	0.201	0.150	0.127
Ridgway Colour	16′ j	16k	19″i
Stones in bulk sample	38.9	55.3	64.6

CLAY FRACTION.

SiO_2/Al_2O_3	2.32	2.35	2.47
SiO_2/R_2O_3	1.75	1.75	2.00
Al_2O_3/Fe_2O_3	3.07	2.92	4.25

FIELD DESCRIPTION.

Topography.—Sharply rolling. *Drainage.*—Good.

Vegetation.—Old pasture untreated.

Profile.—0-10″ Brown light to medium loam ; numerous root fibres.
10-17″ Yellowish-brown to yellow-brown light to medium loam ; stony (shale). 17″+ Yellowish-greyish-brown brashy light loam.
Soil thin on ridges ; mainly colluvial on sedentary sub-soil on features.

TABLE II.

Soil Nos. : S.892-895. *County* : Caernarvonshire. Sheet XLV N.W.
Locality : Ty'n-y-coed, Abersoch.
Geological Data : Ordovician Shale. *Series* : Penrhyn.

ANALYSIS OF AIR-DRY 2mm. SAMPLE.

	S.892 *0–4½″*	*S.893* *4½–9″*	*S.894* *9–13″*	*S. 895* *13–20″*
Coarse Sand	18.6	17.2	16.7	29.4
Fine Sand	23.7	25.2	31.9	42.9
Silt	20.8	22.0	23.2	17.0
Clay	25.3	27.3	22.8	9.6
Moisture	3.50	2.98	2.36	1.28
Calcium Carbonate	Nil	Nil	Nil	Nil

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Loss on ignition	11.34	9.24	6.98	5.11
Org. Carbon	3.86	2.41	1.52	0.36

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pH	5.21	5.00	5.06	5.11
Exch. CaO	0.119	0.105	0.092	0.053
Citric Sol P_2O_5	0.0147	0.0107		
„ „ K_2O	0.0136	0.0062		
Total P_2O_5	0.241	0.213	0.158	0.087
Ridgway Colour	17″ j	17″ j	17″ i-j	19″h-i
Stones in bulk sample	2.8	11.9	14.6	29.3

CLAY FRACTION.

SiO_2/Al_2O_3	2.39	2.37	2.38	2.47
SiO_2/R_2O_3	1.94	1.92	1.91	2.06
Al_2O_3/Fe_2O_3	4.31	4.27	4.07	5.02

FIELD DESCRIPTION.

Topography.—Very slight slope. *Drainage.*—Good. *Vegetation.*—Old pasture of inferior composition.

Profile.—0–4½″ Dark slightly greyish brown medium loam. 4½–9″ Brown slightly stone (entirely shale) medium loam. 9–13″ Slightly yellowish-brown slightly stony medium loam. 13–30″ (on rock) Pale grey-brown stony (shale) medium loam with very fine shale.

TABLE III.

Soil Nos. : S.888-891. *County* : Caernarvonshire. Sheet XI. S.W.
Locality : Bachellyn, Llanbedrog.
Geological Data : Ordovician Shale. *Series* : Cegin.

ANALYSIS OF AIR-DRY 2mm. SAMPLE.

	S.888 *0–7″*	*S.889* *7–16″*	*S.890* *16–24″*	*S.891* *24″ +*
Coarse Sand	7.2	9.9	18.0	27.9
Fine Sand	15.4	20.1	26.6	31.7
Silt	29.5	27.0	25.8	20.3
Clay	34.3	36.8	27.3	18.0
Moisture	4.00	2.84	2.16	1.64
Calcium Carbonate	Nil	Nil	Nil	Nil

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	S.888	*S.889*	*S.890*	*S.891*
Loss on ignition	11.24	6.18	4.48	3.58
Org. Carbon	3.35	0.87	0.31	0.20

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	S.888	*S.889*	*S.890*	*S.891*
pH	5.45	5.42	5.66	5.49
Exch. CaO	0.201	0.141	0.100	0.079
Citric Sol P_2O_5	0.0090	0.0018		
,, ,, K_2O	0.0081	0.0050		
Total P_2O_5	0.194	0.072	0.044	0.071
Ridgway Colour	19‴	19″h	19″	19″h
Stones in bulk sample	Nil	Nil	Nil	Nil

CLAY FRACTION.

	S.888	*S.889*	*S.890*	*S.891*
$SiO_2/Al_2/O_3$	2.47	2.44	2.45	2.53
SiO_2/R_2O_3	2.09	2.01	2.05	2.14
$Al_2O_3Fe_2O_3$	5.50	4.69	5.12	5.48

FIELD DESCRIPTION.

Topography.—Slight slope. *Drainage.*—Impeded. *Vegetation.*—Good old pasture.

Profile.—0–7″ Grey-brown mottled heavy loam. 7–16″ Yellowish-greyish-brown with orange-brown marblings heavy loam to clay loam. 16–24″ Pale yellowish-greyish-brown with yellow-brown marblings, clay loam. 24″+ Pale brownish-grey strongly marbled and mottled with orange-brown concretions, clay loam.

TABLE IV.

Soil Nos. S.922-926. *County* : Caernarvonshire. Sheet XXXII N.E.

Locality : Llanaelhaiarn.

Geological Data : Colluvium derived from rhyolite. *Series* : Unclassified.

ANALYSIS OF AIR-DRY 2mm. SAMPLE.

	S.922 O–4½″	*S.923* *4½–8½″*	*S.924* *9½–16″*	*S.925* *16–20″*	*S.926* *22″+*
Coarse Sand	6.0	10.3	17.7	22.2	32.0
Fine Sand	44.4	37.5	43.7	51.3	51.3
Silt	26.0	19.3	15.3	12.0	7.0
Clay	6.3	11.5	7.8	5.8	3.8
Moisture	3.78	6.76	0.54	0.39	0.13
Calcium Carbonate	Nil	Nil	Nil	Nil n	Nil

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Loss on ignition	17.68	15.42	11.22	7.92	3.72
Org. Carbon	7.33	5.98	3.30	1.83	0.42

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pH	3.98	4.58	4.67	4.81	4.75
Exch CaO	0.028	0.017	0.013	0.009	0.009
Citric Sol. P_2O_5	0.0051	0.0087			
,, ,, K_2O	0.0104	0.0062			
Total P_2O_5	0.056	0.067	0.070	0.058	0.040
Ridgway Colour	21''''	15'h	17''i	15'j-i	18''a
Stones in bulk sample	14.0	36.0	48.0	41.0	53.0

CLAY FRACTION.

SiO_2/Al_2O_3		1.99	1.32	1.17	1.01
SiO_2/R_2O_3		1.41	1.11	1.00	0.93
$Al_2O/_3Fe_2O_3$		2.43	5.29	5.88	10.9

FIELD DESCRIPTION.

Topography.—Sharp slope. *Drainage.*—Good. *Vegetation.*—Mixture of *Erica tetralix, Ulex Gallii,* occasional grasses and *Calluna.* Ground not completely covered ; rooting depth 24″.

Profile.—0–4½″ Dark brown almost black earthy peat ; highly humified transition through 1½″ to 5–8½″ Dark yellow-brown with rapidly diminishing humus content stony sandy loam ; concentrated zone of "B" horizon. 8½–20″ Gradual tailing off of colour down to 20″ where it approx. to "C". 20″ + Pale grey-brown sandy rubble.

TABLE V.

Soil Nos. : S.983-985. *County* : Caernarvonshire. Sheet XLIV N.W.

Locality : Mynydd Rhiw.

Geological Data : Colluvium derived from quartz dolerite. *Series* : Rhiw.

ANALYSIS OF AIR-DRY 2mm SAMPLE.

	S.983 *0-6″*	*S.984* *6-12″*	*S.985* *12-17″*
Coarse Sand	11.5	27.8	39.3
Fine Sand	33.6	33.5	40.3
Silt	15.3	14.5	12.0
Clay	19.0	14.5	6.5
Moisture	5.08	4.06	2.64
Calcium Carbonate ..	Nil	Nil	Nil

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Loss on ignition ..	20.96	11.62	6.24
Org. Carbon	11.21	5.25	1.60

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pH	5.12	5.12	5.25
Exch CaO	0.078	0.045	0.018
Citric Sol. P_2O_5 ..	0.0100		
,, ,, K_2O ..	0.0178		
Total P_2O_5	0.193	0.140	0.113
Ridgway Colour ..	16′k	15′i	15′i-j
Stones in bulk sample	10.0	33.7	45.2

CLAY FRACTION.

SiO_2/Al_2O_3	2.87	2.44	2.00
SiO_2/R_2O_3	1.87	1.44	1.27
Al_2O_3/Fe_2O_3	1.87	1.44	1.74

FIELD DESCRIPTION.

Topography.—Boulder-strewn scree slope. Rock pavement in places; soil pockety.

Drainage.—Good. *Vegetation.*—Grassy heath with heather (tetralix) and gorse (Gallii) dominant in places. Fair amount of wild white clover.

Profile.—0-6″ Dark brown peaty loam. 6-12″ Brown slightly peaty stony loam. 12-17″ Yellowish cinnamon-brown brashy light loam.

TABLE VI.

Soil Nos. : S.909-912. *County* : Caernarvonshire. Sheet XLV. **N.W.**

Locality : Brynffynnon, Mynytho.

Geological Data : Porphyritic Rhyolite. *Series* : Arvon.

ANALYSIS OF AIR-DRY 2mm SAMPLE.

	S.909 *0-8″*	*S.910* *8-12″*	*S.911* *12-18″*	*S.912* *18″+*
Coarse Sand	14.9	17.0	18.9	19.9
Fine Sand	33.1	34.2	37.3	37.6
Silt	20.3	23.0	26.8	21.8
Clay	18.3	18.6	15.0	14.0
Moisture	3.50	2.60	1.42	1.56
Calcium Carbonate	Nil	Nil	Nil	Nil

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Loss on ignition	11.32	6.78	4.06	3.64
Org. Carbon	3.55	1.43	0.53	0.22

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pH	5.51	5.28	5.40	5.51
Exch. CaO	0.213	0.064	0.051	0.066
Citric Sol. P_2O_5	0.0212	0.0117		
,, ,, K_2O	0.0151	0.0062		
Total P_2O_5	0.215	0.161	0.070	0.080
Ridgway Colour	16″j	17′i	18″h	17″a
Stones in bulk sample ..	9.37	11.74	10.85	18.59

CLAY FRACTION.

SiO_2/Al_2O_3	2.57	2.16	2.16	2.67
SiO_2/R_2O_3	1.93	1.62	1.72	2.09
Al_2O_3/Fe_2O_3	3.01	3.00	3.82	3.60

FIELD DESCRIPTION.

Topography.—Slight slope. *Drainage.*—Good. *Vegetation.*—Temporary pasture of poor composition.

Profile.—0-8″ Dark slightly greyish brown slightly stony light loam. 8-12″ Bright yellowish-brown slightly stone light loam. 12-18″ Pale slightly greyish-yellowish-brown slightly stony light loam. 18″+ Greyish-yellowish-brown stony light to medium loam.

TABLE VII.

Soil Nos. : S.857-859. *County* : Caernarvonshire. Sheet XXXIII. S.W.

Locality : Plas Gwyn, Fourcrosses.

Geological Data : Shallow drift derived mainly from rhyolite. *Series* : Arvon.

ANALYSIS OF AIR-DRY 2mm. SAMPLE.

	S.857 *0-11″*	*S.858* *11-17″*	*S.859* *17-27″*
Coarse Sand	12.5	16.4	39.4
Fine Sand	31.0	29.1	29.5
Silt	25.8	27.5	16.5
Clay	19.8	19.3	12.8
Moisture	3.04	2.90	1.46
Calcium Carbonate	Nil	Nil	Nil

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Loss on ignition	10.90	6.90	3.84
Org. Carbon	4.06	1.65	0.37

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pH	5.00	4.87	5.03
Exch. CaO	0.047	0.025	0.019
Citric Sol. P_2O_5	0.0140	0.0171	
,, K_2O	0.0062	0.0096	
Total P_2O_5	0.219	0.219	0.114
Ridgway Colour	14′j	15′j	17″j-17‴
Stones in bulk sample	8.2	22.7	46.4

CLAY FRACTION.

SiO_2/Al_2O_3	2.20	1.94	2.47
SiO_2/R_2O_3	1.68	1.54	2.01
Al_2O_3/Fe_2O_3	3.23	3.85	4.40

FIELD DESCRIPTION.

Topography.—Gentle slope. *Drainage.*—Good. *Vegetation.*—Oat stubble.

Profile.—0-11″ Dark brown slightly stony light to medium loam. 11-17″ Yellowish-brown pebbly light to medium loam. 17-27″ Pale grey-yellow-brown pebbly almost brashy gritty light loam.

TABLE VIII.

Soil Nos. : S.819-821. *County* : Caernarvon. Sheet XXXIII. S.W.

Locality : Glanrafon, Bodfean.

Locality : Glanrafon, Bodfean.

Geological Data : Mixed drift with preponderance igneous. Series : Arvon.

ANALYSIS OF AIR-DRY 2mm SAMPLE.

	S.819 *0-10"*	*S.820* *10-18"*	*S.821* *18-21"*
Coarse Sand	22.05	34.63	40.77
Fine Sand	29.4	35.4	31.3
Silt	20.0	22.3	20.3
Clay	16.3	6.3	7.8
Moisture	3.20	0.98	1.02
Calcium Carbonate	Nil	Nil	Nil

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Loss on ignition	11.06	3.94	3.62
Org. Carbon	4.38	0.36	0.22

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pH	5.14	5.07	5.65
Exch. CaO	0.130	0.051	0.073
Citric Sol. P_2O_5	0.0117	0.0077	
,, ,, K_2O	0.0136	0.0062	
Total P_2O_5	0.220	0.101	0.113
Ridgway Colour	15'j	18"h	18"h
Stones, in bulk sample			

CLAY FRACTION

SiO_2/Al_2O_3	2.44	2.54	2.37
SiO_2/R_2O_3	1.91	2.07	1.92
$Al_2/O_3Fe_2O_3$	3.59	4.39	4.33

FIELD DESCRIPTION.

Topography.—Slight slope. *Drainage.*—Good. *Vegetation.*—Fair temporary pasture.

Profile.—0-10" Slightly greyish-brown slightly stony light loam. 10-18" Yellowish-brown stony light loam.
18"+ Greyish-yellowish-brown stony to rubbly light loam.

TABLE IX.

Soil Nos. : S.925-928. *County* : Caernarvonshire. Sheet XL. N.E.

Locality : Bodvel, Llannor.

Geological Data : Boulder Clay derived from igneous rocks. *Series* : Eivion.

ANALYSIS OF AIR-DRY 2mm. SAMPLE.

	S.825 *0-6"*	*S.826* *6-12"*	*S.827* *12-17"*	*S.828* *20-26"*
Coarse Sand	8.9	9.6	5.9	6.7
Fine Sand	29.9	32.0	27.1	24.6
Silt	26.8	27.8	29.3	30.3
Clay	22.4	22.8	33.4	33.6
Moisture	3.36	2.62	2.06	2.74
Calcium Carbonate	Nil	Nil	Nil	Nil.

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Loss on ignition	12.40	7.78	4.52	5.28
Org. Carbon	5.74	2.89	0.45	1.09

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pH	4.55	4.68	4.68	5.68
Exch. CaO	0.047	0.071	0.105	0.167
Citric Sol. P_2O_5	0.0118	0.0095		
,, ,, K_2O	0.0120	0.0074		
Total P_2O_5	0.130	0.125	0.043	0.048
Ridgway Colour	19'''	19''a	20''	17'h
Stones in bulk sample	n.d.	n.d.	n.d.	n.d.

CLAY FRAACTION

SiO_2/Al_2O_3	2.69	2.42	2.64	2.38
SiO_2/R_2O_3	2.13	1.99	1.93	1.72
Al_2O_3/Fe_2O_3	3.83	4.63	3.63	2.49

FIELD DESCRIPTION.

Topography.—Slight slope. *Drainage.*—Impeded.

Vegetation.—Fair pasture with rushes.

Profile.—0-6" Dark grey-brown heavily mottled silt loam. 6-12" Slightly paler, heavy silt loam ; heavily mottled. 12-24" Pale variegated greyish-yellow-browns having appearance of marblings ; silt clay. 24"+ Slightly greyer and stiffer ; silt clay. Profile generally stoneless excepting occasional large boulders.

TABLE X.

Soil Nos. : S.971-975. *County* : Caernarvonshire. Sheet XXXIII. N.E

Locality : Ynys, Nr. Criccieth.

Geological Data : Peat on Boulder Clay. *Series* : Ynys.

ANALYSIS OF AIR-DRY 2mm. SAMPLE.

	S.971 *0-7″*	*S.972* *7.13″*	*S.973* *13.18″*	*S.974* *18.32″*	*S.975* *32″+*
Coarse Sand			20.1	28.0	21.1
Fine Sand			26.7	31.5	21.7
Silt			27.0	25.5	32.3
Clays			14.4	14.5	25.5
Moisture	11.32	10.28	2.94	1.32	1.02
Calcium Carbonate	Nil	Nil	Nil	Nil	Nil

* * * * *

Loss on ignition	74.48	62.40	13.94	4.94	5.00
Org. Carbon	43.60	40.64	8.88	1.31	1.10

* * * * *

pH	4.18	4.39	4.61	4.58	4.43
Exch. CaO	0.228*	0.169	0.038	0.034	0.025
Citric Sol. P_2O_5	0.0229				
,, ,, K_2O	0.0400				
Total P_2O_5	0.300	0.333	0.109	0.036	0.036
Ridgway Colour			21‴b	20‴	20.‴b
Stones in bulk sample	Nil	Nil.	13.0	13.4	35.2

CLAY FRACTION.

SiO_2/Al_2O_3			2.70	2.43	2.60
SiO_2/R_2O_3			2.49	2.15	2.27
Al_2O_3/Fe_2O_3			11.9	7.69	7.00

FIELD DESCRIPTION.

Topography.—Almost flat. *Drainage.*—Bady impeded.

Vegetation.—Poor rushy grazing.

Profile.—0-7″ Dark brown fibrous peat. 71-2″. Black humified peat 13-18″ Grey-brown peaty loam; mottled. 18-32″ Brownish-grey silt loam; mottled and marbled. 32″+ Bluish-grey silt loam; mottled and marbled.

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*The exchangeable lime status of these soils is not as high as the figure quoted would suggest. Calculated on a wet-weight basis, the figure is very considerably lower.

TABLE XI.

Soil No. : S.995-999. *County* : Caernarvonshire. Sheet : XXXIII. N.E.

Locality : Bryn-yr-efail Uchaf, Glandwyfach.

Geological Data : Acid igneous rocks. *Series* : Ynys (improved).

ANALYSIS OF AIR-DRY 2mm. SAMPLE.

	S.995 *0-8″*	*S.996* *8-11″*	*S.997* *12-14″*	*S.998* *14-20″*	*S.999* *24″+*
Corse Sand	17.1	45.1	40.6	37.8	41.4
Fine Sand	20.1	17.2	18.6	20.4	19.6
Silt	29.9	21.8	26.3	23.5	26.0
Clay	21.5	13.2	14.2	13.4	11.5
Moisture	3.70	2.60	2.00	2.48	1.58
Calcium Carbonate ..	Nil	Nil	Nil	Nil	Nil

* * * * *

Loss on ignition ..	15.82	7.36	5.48	6.14	4.84
Org. Carbon	7.34	1.97	1.29	1.44	1.00

* * * * *

pH	5.48	5.46	5.82	5.69	5.94
Exch. CaO	0.334	0.183	0.114	0.096	0.058
Citric Sol. P_2O_5 ..	0.0190				
„ „ K_2O ..	0.0085				
Total P_2O_5	0.236	0.109	0.111	0.127	0.104
Ridgway Colour ..	17‴i	16′i	18″i	18″i	19″i
Stones in bulk sample ..	18.3	54.9	49.3	46.7	58.1

CLAY FRACTION.

SiO_2/Al_2O_3	2.94	2.54	2.74	2.27	2.09
SiO_2/R_2O_3	2.40	1.88	2.17	1.80	1.70
Al_2O_3/Fe_2O_3	4.44	2.85	3.80	3.83	4.36

FIELD DESCRIPTION.

Topography.—Slight slope. *Drainage.*—Fair ; mimpedence in lower layers. *Vegetation.*—Weedy *Agrostis* pasture.

Profile.—0-8″ Dark brown fibrous peaty silt loam ; very slight or almost free from mottling. 8-10 or 11″ Dark rust-brown ferruginous layer ; rather irregular in width ; stony ; mottled. 11-13″ Pale brownish-grey with yellow-brown mottling brashy loam. 11″+ Fairly uniform grey-brown with ochreous mottlings, becoming more numerous with depth ; brashy loam.

TABLE XII.

Soil Nos. : S.976-982. *County* : Caernarvonshire. Sheet XLIII. N.E.

Locality : Methlan, Rhoshirwaen.

Geological Data : Boulder clay of Northern origin. Carboniferous. *Series* : Dinas.

ANALYSIS OF AIR-DRY 2mm. SAMPLE.

	S.976 *0-6″*	*S.977* *6-11″*	*S.978* *12-18″*	*S.979* *18-24″*	*S.980* *24-30″*	*S.981* *30-36″*	*S.982* *36-43″*
Coarse Sand	11.9	13.2	9.1	9.8	8.0	8.0	8.8
Fine Sand	34.2	36.8	32.1	32.7	31.6	30.7	30.0
Silt ..	20.3	21.3	21.8	21.8	21.5	21.3	21.8
Clay ..	23.5	26.2	36.5	34.7	31.0	29.7	29.7
Moisture	2.48	1.72	2.32	2.04	1.64	1.70	1.54
Calcium Carbonate	Nil	Nil	Nil	0.21	8.93	10.25	9.58
		*	*	*	*	*	
Loss on ignition	11.24	5.72	4.44	4.22	7.96	8.48	8.08
Org. Carbon	4.82	1.73	0.56	0.36	0.27	0.45	0.27
		*	*	*	*	*	
pH ..	5.69	6.00	6.90	8.14	8.34	8.20	8.27
Exch. CaO	0.248	0.178	0.219	0.308	0.275	0.238	0.196
Citric Sol. P_2O_5	0.012						
,, ,, K_2O	0.009						
Total P_2O_5	0.083	0.045	0.042	0.062	0.075	0.090	0.087
Ridgway Colour	17‴i	17″j	17′i	17′j	17″j	17″j	17″j
Stones in bulk sample..	Nil	Nil	Nil	Nil	Nil	Nil	Nil

CLAY FRACTION.

SiO_2/Al_2O_3	3.21	2.82	3.14	2.99	3.53	3.71	3.29
SiO_2/R_2O_3	2.53	2.25	2.49	2.37	2.70	2.79	2.57
Al_2O_3/Fe_2O_3	3.72	4.00	3.83	3.82	3.25	3.09	3.57

FIELD DESCRIPTION.

Topography.—Moderate slope. *Drainage.*—Seasonal wetness. *Vegetation.*—Pasture of fairly good composition. *Profile.*—0-7″ Greyish brown heavy loam. 7-11″ Greyish-yellowish-brown. 10-12″ Transition to raw clay. 12-18″ Yellowish-brown finely marbled with grey streaks. On fracture faces (natural) colour fairly uniform pale brownish-grey. 18″+ Increasingly greyish, marbled with yellow and orange. Calcareous ; becoming very pronounced below 24″. Evidence of seasonal wetness throughout. Dark manganiferous fragments general below 12″. Stoneless.

TABLE XIII.

Soil Nos. : S.944-946. *County* : Caernarvonshire. Sheet XLIV S.W.

Locality : Blawtty, Llanfaelrhys.

Geological Data : Northern drift of Carboniferous origin. *Series* : Cadlan.

ANALYSIS OF AIR-DRY 2mm. SAMPLE.

	S.944	*S.945*	*S.946*
	0-7″	*12-20″*	*22″+*
Coarse Sand	14.4	15.8	15.5
Fine Sand	36.8	43.7	36.8
Silt	20.0	20.0	26.8
Clay	21.1	18.9	19.0
Moisture	2.24	1.72	1.84
Calcium Carbonate ..	Nil	Nil	Nil

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Loss on ignition ..	9.58	3.86	3.36
Org. Carbon	4.10	0.70	0.32

* * * * *

pH	4.87	5.24	5.24
Exch. CaO	0.094	0.061	0.089
Citric Sol. P_2O_5 ..	0.0140		
,, ,, K_2O ..	0.0084		
Total P_2O_5	0.214	0.117	0.071
Ridgway Colour ..	17″j	17″h-i	15′i
Stones in bulk sample	11.6	13.7	9.5

CLAY FRACTION.

SiO_2/Al_2O_3	2.91	2.64	2.86
SiO_2/R_2O_3	2.31	2.14	2.32
Al_2O_3/Fe_2O_3	3.85	4.28	4.85

FIELD DESCRIPTION.

Topography.—Slight slope. *Drainage.*—Good. *Vegetation.*—Fair old pasture.

Profile.—0-7″ Slightly dark greyish-brown gradually changing to slightly greyish brown, medium loam.
7-20″ Yellowish-brown, medium loam. 22″+ Greyish-yellowish-brown with mottlings and marblings, medium loam becoming stiffer with depth.

TABLE XIV.

Soil Nos. : 947-950. *County* : Caernarvonshire. Sheet XXXIX.NW.

Locality : Tan-llan, Tydweiliog.

Geological Data : Northern drift with sandy wash. *Series* : Tydweiliog.

ANALYSIS OF AIR-DRY 2mm. SAMPLE.

	S.947 *0-7"*	*S.948* *7-16"*	*S.949* *16-24"*	*S.950* *30"+*
Coarse Sand ..	26.4	22.4	24.3	7.1
Fine Sand ..	49.6	57.4	46.7	38.0
Silt	7.5	8.0	13.8	29.5
Clay	11.4	11.3	14.0	23.0
Moisture	1.24	0.84	1.18	1.66
Calcium Carbonate	Nil	Nil	Nil	0.87

* * * * * *

Loss on ignition ..	5.20	2.48	2.00	2.92
Org. Carbon ..	2.37	0.70	0.24	0.20

* * * * *

pH	5.07	5.43	6.39	7.46
Exh. CaO	0.1040	0.091	0.147	0.271
Citric Sol. P_2O_5 ..	0.0136			
,, ,,K_2O ..	0.0054			
Total P_2O_5 ..	0.103	0.057	0.074	0.104
Ridgway Colour ..	17'''i	19''h.	17'i	17''j
Stones in bulk sample	2.8	14.9	35.8	6.4

CLAY FRACTION.

SiO_2/Al_2O_3 ..	2.88	2.74	3.01	3.19
SiO_2/R_2O_3	2.26	2.18	2.25	2.53
Al_2O_3/Fe_2O_3 ..	3.77	3.89	2.96	3.83

FIELD DESCRIPTION.

Topography.—Very slight slope. *Drainage.*—Impeded. *Vegetation.*—Fair old pasture with occasional rushes.

Profile.—0-16" Fairly uniform dark greyish-brown mottled silty sand to stoneless sandy light loam. Root fibres throughout and terminating abruptly. 16-24" Sharp transition to grey-brown and yellow-brown gritty and slightly pebbly loam. Increasingly stiff with increasing depth. 24"+ Brownish-grey with yellow-brown marblings heavy loam.

TABLE XV.

*Soil Nos. S.*860-865. *County* : Caernarvonshire. Sheet XXXIX. N.E.

Locality : Bronheulog, Ceidio.

Geological Data : Glacial sand of Carboniferous origin. *Series* : Bodvel.

ANALYSIS OF AIR-DRY 2mm.SAMPLE.

	S.860 *0-5″*	*S.861* *5-10″*	*S.862* *10-15″*	*S.863* *15-27″*	*S.864* *27-37″*	*S.865* *37″+*
Coarse Sand ..	18.8	20.4	9.8	1.0	9.6	21.6
Fine Sand ..	60.0	59.5	75.8	88.7	80.5	74.5
Silt	9.2	10.2	5.8	11.2	8.8	3.3
Clay	7.0	6.3	5.8	Trace	2.3	0.3
Moisture	1.30	1.02	0.70	0.52	0.56	0.28
Calcium Carbonate	Nil	Nil	Nil	Nil	Nil	Nil
	*	*	*	*	*	
Loss on ignition ..	5.56	3.84	2.34	1.72	1.26	0.98
Org. Carbon ..	2.70	1.34	0.42	0.16	0.11	0.05
	*	*	*	*	*	
pH	4.89	5.00	5.40	5.31	5.72	5.69
Exch. CaO ..	0.029	0.030	0.028	0.022	0.027	0.020
Citric Sol. P_2O_5	0.0107	0.0078				
,, ,, K_2O ..	0.0074	0.0062				
Total P_2O_5 ..	0.118	0.094	0.052	0.034	0.037	0.044
Ridgway Colour ..	17″h	17″j	17″i	17″j	17″i	17″j
Stones in bulk sample	Nil	Nil	Nil	Nil	Nil	Nil

CLAY FRACTION.

SiO_2/Al_2O_3 ..	2.81	2.48	2.36	1.83	2.52	2.41
SiO_2/R_2O_3	2.09	1.85	1.82	1.50	1.99	1.87
Al_2O_3/Fe_2O_3 ..	2.90	3.00	3.37	4.50	3.76	3.47

FIELD DESCRIPTION.

Topography.—Sharply undulating. *Drainage.*—Very free liable to drought. *Vegetation.*—Poor pasture.

Profile.—0-5″ Greyish-brown fibrous loamy sand; occasional well rounded pebbles. 5-10″ Brown, essentially similar in texture; stoneless. 10-15″ Light brown fine sand; stoneless. 15-27″ Pale grey-brown fine sand; stoneless. 27-37″ Pale grey-brown with cemented clods of dark reddish-brown, stoneless, fine sand. 37″+ Pale grey-brown fine sand; stoneless.

TABLE XVI.

Soil Nos.: S.883-887. *County*: Caernarvonshire. Sheet XL S.E. XL1. S.W.

Locality: Gelli Dara, Penrhos, Pwllheli.

Geological Data: Gravelly Northern Drift. *Series*: Bodvel.

ANALYSIS OF AIR-DRY 2mm. SAMPLE.

	S.883 0-6″	*S.884 6-12″*	*S.885 12-18″*	*S.886 18-24″*	*S.887 24″+*
Coarse Sand	31.4	32.2	30.8	35.3	49.7
Fine Sand	37.8	38.3	40.3	39.6	27.0
Silt	9.8	12.5	11.5	11.3	11.8
Clay	13.3	12.3	12.5	10.1	9.3
Moisture	1.90	1.72	2.14	1.68	1.26
Calcium Carbonate	Nil	Nil	Nil	Nil	Nil

* * * * *

Loss on ignition	6.60	4.58	4.22	3.58	2.92
Org. Carbon	2.01	1.17	0.80	0.60	0.34

* * * * *

pH	5.66	5.38	5.51	5.45	5.52
Exch. CaO	0.155	0.101	0.066	0.050	0.032
Citric Sol. P_2O_5	0.0075	0.0051			
,, ,, K_2O	0.0081	0.0027			
Total P_2O_5	0.156	0.138	0.122	0.108	0.095
Ridgway Colour	15'j	13'j	15'i-j	15'i	15'j
Stones in bulk sample	3.88	17.4	18.0	28.7	32.0

CLAY FRACTION.

SiO_2/Al_2O_3	2.67	2.58	2.17	2.20	2.69
SiO_2/R_2O_3	1.97	1.88	1.61	1.73	2.07
Al_2O_3/Fe_2O_3	2.81	2.69	2.88	3.70	3.30

FIELD DESCRIPTION.

Topography.—Very slight slope. *Drainage.*—Good. *Vegetation.*—Old pasture of fair quality.

Profile.—0-6″ Dark greyish brown sandy light loam; pebbly. 6-12″ Dark slightly reddish-brown, pebbly, sandy light loam. 12-18″ Orange-brown pebbly, sandy light loam. 18-24″ Yellowish-brown increasing pebbly sandy light loam. 24″+Pale slightly greyish-brown very pebbly light loam.

TABLE XVII.

Soil Nos. : S.843-846. *County* : Caernarvonshire. Sheet XL N.W.

Locality : Madryn Castle, Bodfean.

Geological Data : Northern drift with admixture of igneous and shale rock. *Series* : Madryn.

ANALYSIS OF AIR-DRY 2mm. SAMPLE.

	S.843 *0-7"*	*S.844* *7.-14"*	*S.845* *14-21"*	*S.846* *22-28".*
Coarse Sand	18.7	20.6	17.0	18.9
Fine Sand	39.8	42.5	52.0	62.4
Silt	14.3	16.3	17.0	12.5
Clay	16.3	15.1	10.8	5.8
Moisture	2.66	2.06	1.50	0.84
Calcium Carbonate	Nil	Nil	Nil	Nil

* * * * *

	S.843	*S.844*	*S.845*	*S.846*
Loss on ignition	8.96	5.04	3.82	2.32
Org. Carbon	3.71	1.53	0.82	0.24

* * * * *

	S.843	*S.844*	*S.845*	*S.846*
pH	5.14	5.21	4.98	5.38
Exch. CaO	0.114	0.044	0.033	0.017
Citric Sol. P_2O_5	0.0232	0.0085		
,, ,,K_2O	0.0072	0.0036		
Total P_2O_5	0.193	0.133	0.166	0.076
Ridgway Colour	15'j	15'k	15'j-k	15'i
Stones in bulk sample	2.5	7.6	11.1	5.2

CLAY FRACTION

	S.843	*S.844*	*S.845*	*S.846*
SiO_2/Al_2O_3	2.32	2.31	2.29	2.15
SiO_2/R_2O_3	1.77	1.74	1.76	1.77
Al_2O_3/Fe_2O_3	3.19	3.00	3.29	4.64

FIELD DESCRIPTION.

Topography.—Gentle slope. *Drainage.*—Good. *Vegetation.*—*Agrostis* pasture.

Profile.—0-7" Slightly greyish brown sandy light to medium loam ; 7-14" Slightly yellowish dull brown sandy light to medium loam ; slightly stony. 14-21" Yellow-brown fine sandy loam ; slightly pebbly. 22-28" Pale yellow-brown slightly pebbly fine sandy loam.

THE GROWING OF CHRYSANTHEMUMS AND OTHER PLANTS IN WIRE POTS.

BY H. L. JONES, N.D.H.
Padeswood Hall Demonstration Centre, Mold, Flintshire.

As a commercial crop the Chrysanthemum stands high in merit. At one time all Chrysanthemums for indoor flowering were grown in earthenware pots, and most growers can well remember seeing plants standing in such pots supported by stakes attached to a wire stretched from one end of the row to the other to prevent them from being blown about by strong winds. Plants so grown needed the closest attention during the summer as well as towards the latter part of the season, and involved most of the time of one man. After the War, this labour was not available, and growers developed a rougher and cruder method. The plants were raised in moderate heat, hardened off, and some time in April or May were planted out in rows in the open ground with little, if any, attention to watering. When the time came to house such plants towards the end of September or early in October, they were carefully lifted with a spade and planted in the border of the house. They were flowered in the houses, and the old stools were thrown away after cuttings had been taken for the following year. Some of the best varieties failed to respond to this rough treatment, and were grown in earthenware pots. When they had rooted well, they were plunged in the open garden and subsequently flowered under glass, and the labour involved in keeping them watered was thus reduced. This method of growing was not satisfactory, and owing to the damage to the pots by the weather, proved to be too costly. Although when well grown these varieties often gave the best flowers, generally speaking they did not lift well and had to be discarded, and only those varieties that produced large quantities of fine roots, which retained the soil at lifting, were grown commercially. Attempts made to produce a substitute for the earthenware pot by means of pressed paper, cardboard, and other materials proved unsuitable and uneconomical until the introduction of wire pots three or four years ago. These wire pots have proved very suitable for growing plants other than Chrysanthemums which are grown out of doors during the summer, then brought under glass to bloom, and sometimes potted on to earthenware pots to be marketed.

Wire pots have been tested at the Padeswood Hall Demonstration Centre during the last two years, and have been found most suitable. Two hundred plants of different types, Chrysanthemums, Solanums, etc., were grown in these pots and the same number in earthenware pots; their behaviour was watched throughout the two seasons, and in every case, the advantage was with the wire pots. In the case of the Chrysanthemums, the "wire pot" plants produced better and more numerous flowers, and the blooms sold at 40% to 50% better prices than those grown in earthenware pots. The advantage of wire pots is that when they are planted out, the roots are able to spread to the adjoining ground, whilst those of plants in earthenware pots are confined to the pot, apart from a few which manage to grow out through the drainage hole in the base of the pot. The plants in the earthenware pots had to be watered frequently, whilst those in the wire pots did not need such attention, as their roots were able to obtain moisture from the outside soil.

At lifting time the plants were easier to handle than either the open ground plants or those grown in pots, and all that was required was a fork to lift them. The plants in every case lifted with a nice ball of roots outside the wires and when planted in the borders, rooted in the soil straight away without any check to growth. Another advantage was that they could be carried about without any risk of the soil dropping from the roots.

Solanums were grown in wire pots in an ordinary frame, and in every case the resultant plant was superior to that grown in earthenware pots. After growing in 3½″ wire pots they were transferred to ordinary pots for marketing.

When these wire pots become better known, they will be used by growers for very many plants. Such varieties of Cupressus as Macrocarpa could be grown successfully in a 2½″ or 3″ wire pot, and sold with the pot as cheaply as those grown and potted up for sale. When planted out in the Spring, they would soon become established and make better plants than those taken out of an ordinary pot for planting out.

Autumn sown cauliflowers can be potted up into wire pots in January, and the plants planted out in April with very satisfactory results. The pots can be recovered when the crop is pulled up, and are good for future years.

From the photographs reproduced may be seen (Fig. 1, Plate 1) a Chrysanthemum plant, variety "Favourite," showing the sturdiness of the plant, the healthy foliage and the absence of flagging or drooping of the leaves. This variety is a notoriously bad lifter from open ground, and several growers have given up growing it because of this trait. The plant shown produced eight excellent flowers, whilst those from earthenware pots gave four only of inferior quality. The open ground plants gave five flowers,

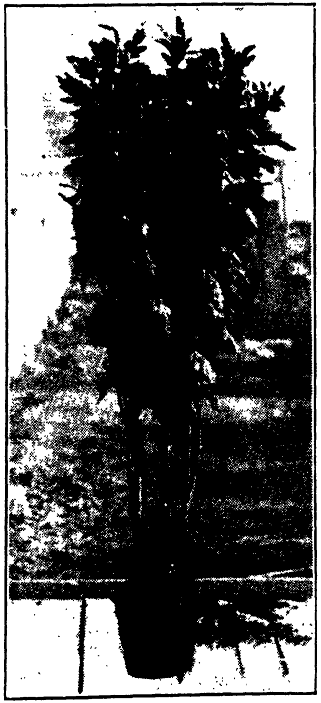

FIG 1.—CHRYSANTHEMUM VARIETY "FAVOURITE."

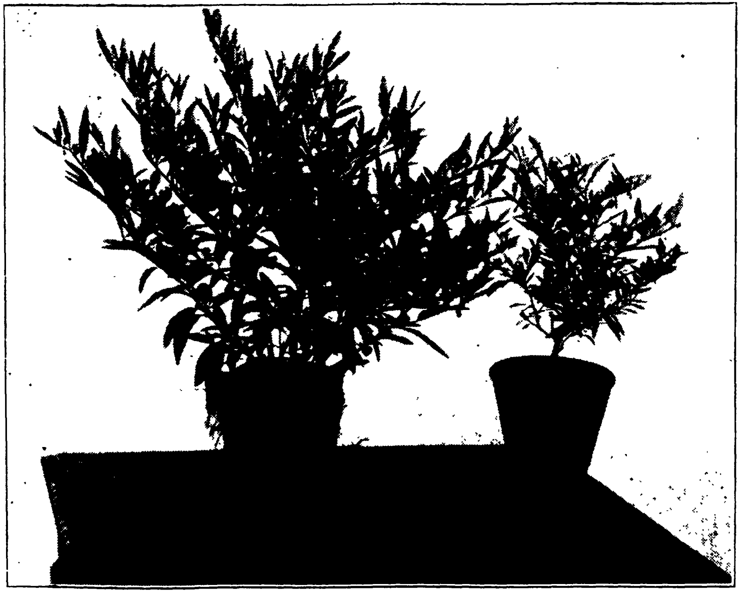

FIG 2.—SOLANUMS.

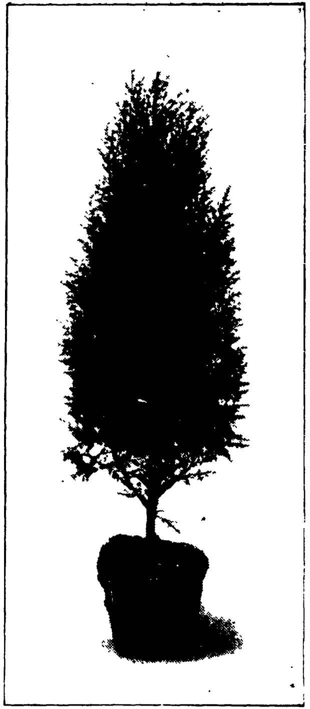

FIG 3.—CUPRESSUS MACROCARPA.

which were also much inferior to those grown in the wire pots. Another striking fact was the absence of Mildew and such pests as Leaf Miner and Aphis on the plants in the wire pots, whilst the other plants, despite several sprayings with nicotine, suffered severely from both Mildew and a bad attack of Leaf Miner.

The superiority of the Solanum grown in the wire pot as compared with that grown in the earthenware pot is amply borne out by the photograph (Fig. 2, Plate II). Moreover, the wire pot plant was sold at 50% more than the other.

The third photograph (Fig. 3, Plate III) shows a plant of Cupressus Macrocarpa ready to be planted out into its future home. This plant had stood out all day before the photograph was taken, yet it had not flagged or suffered in any way. In this case, the pot is sold with the plant, as is customary when this species is grown in the ordinary pot, and as the price of the wire pot is half that of the other, and the result is far superior, the advantage of the wire pot is unquestionable.

The price of a 3″ wire pot is very slightly over ½d. that of the 4″ pot a fraction over 1d. and that of the 7″ × 4¾″ is under 2d. With regard to the lasting qualities of these pots, there are ample grounds for estimating that they will last from 8-10 years. The 7″ × 4¾″ pots tested at Padeswood Hall Demonstration Centre are as good to-day as when they were used for the first time and tests carried out show that galvanised wire pots are unequalled.

POULTRY DISEASES IN NORTH WALES. REFLECTIONS FROM LABORATORY OBSERVATIONS.

By W. T. Rowlands, M.R.C.V.S., D.V.S.M.
University College, Bangor.

Although probably the greatest number of poultry in North Wales or indeed in Wales generally, are kept under general farm conditions as barn-yard stock, poultry keeping on specialised lines is also responsible for no small fraction of the total population. It is obvious too, that general farmers, perhaps more particularly their wives, are becoming more and more poultry-minded and find that they are able to make a small but nevertheless acceptable income from such a sideline.

There are good grounds for believing that an increase in the number of poultry of indifferent stamina, due to faulty management and excessive strains of production, is largely responsible for much of the disease problem generally. Observations made at this laboratory during post-mortem examinations over a number of years fully confirm this. The large percentage of deaths diagnosed as due to chilling, or some other form of mismanagement with resultant pneumonia and enteritis, and the high incidence of cases where death was due to some undefined cause, together with an associated history of heavy culling in the original flock, are direct evidence of this.

Although possibly through lack of sufficient knowledge, the poultry-keeper himself is to be blamed for mismanagement of originally healthy stock, a great deal of trouble is certainly experienced through the purchase of foundation stock of low stamina. Consequently the practise of culling is far more common than should be necessary, were strong healthy stock used as a basis for the future flock. One deprecates too, the practise of purchasing stock, at possibly a cheap rate, from outside the Principality which is a feature on some farms in North Wales, particularly so, when through the praiseworthy efforts of the County Poultry Instructors excellent local sources of healthy stocks have been made available. It is the exception at this laboratory, for instance, to diagnose B.W.D. in chicks purchased from within the Principality and it is the rule to find that chicks dying from B.W.D. were purchased from "outside." Similarly, a large number of losses are experienced in young chicks following unnecessarily lengthy rail journeys with excellent sources of supply close at hand. It is a matter of no little concern that these facts are not more generally appreciated, particularly among general farmers who appear to be the worst offenders in this case.

For several years it was taught that Fowl Typhoid, a disease capable of decimating a poultry flock in a very short period of time, was closely linked with Wales, and the unhygienic conditions prevailing on general farms, to which it was exclusively confined. The confirmation of Fowl Typhoid outbreaks both outside the Principality and under some of the best conditions of poultry husbandry have now served, in part, to remove this stigma. It must be clearly understood, however, that Fowl Typhoid is still a disease with which poultry keepers have to seriously contend in Wales, and that it is definitely associated with unhygienic methods. It appears rampant in certain districts and infection is very often introduced by contaminated water supplies. Although the disease can be suspected by a heavy death rate, the appearance of a greenish diarrhoea and discoloration of the comb, a final diagnosis must be based upon a bacteriological examination. The value of *vaccination* in outbreaks of Fowl Typhoid is perhaps variable but in general can be claimed to considerably reduce the mortality rate. Work recently conducted here to decide whether such vaccination can, at a subsequent date, have any effect upon the blood test for B.W.D. carriers in birds so inoculated indicates quite clearly that the vaccine issued by the Ministry of Agriculture and inoculated subcutaneously has no effect upon such later tests.

In reference to blood testing, experience obtained at this laboratory indicates that it is an excellent method of eradicating B.W.D. carriers, thus preventing an outbreak of the disease in chicks from such a source. It must not be assumed that, like any other biological test, it is 100 % efficient. Provided, however, the samples are well taken and the results correctly interpreted it can be regarded as very accurate for the purpose employed, even though an occasional bird which is not a "carrier" reacts or conversely a "carrier" birds fails to react. It is important to realise that the actual disease, which again, can only be diagnosed definitely by laboratory examination, can affect adult birds on occasions, as well as chicks and conversely that Fowl Typhoid primarily a disease of adult birds can and does, at times, cause heavy chick losses. As with Fowl Typhoid, so with B.W.D. special regard to hygiene with particular regard for a clean water supply are the main features in preventing the spread of infection. Unlike Fowl Typhoid, there seems to be little value in vaccination against B.W.D. and treatment of any sort in affected birds cannot be regarded as of any value, prevention being the object at which to aim.

Heavy mortalities due to Fowl Cholera are sometimes met with in Wales. In the majority of instances, apart from a short period of great dullness and dejection, no symptoms are noted and an owner is faced with a number of deaths among birds previously apparently healthy. The disease is highly infectious and in most cases is introduced either with newly purchased stock or by infected crates. In the event of such an outbreak, if it is confined to a certain section of the poultry, strict isolation of healthy stock, with separate attendance, should be practised immediately. Vaccination, although available, is of doubtful value in this respect and treatment must depend upon the destruction of in-contact birds in order to limit infection as much as possible.

Although the foregoing diseases can be met with on any type of farm, tuberculosis among poultry can be claimed to be the curse of the barn-yard flock. As in all species of animals affected with this disease older animals are more commonly affected. This does not necessarily mean however that infection is not picked up when the birds were young or that it cannot cause the death of young birds—it can. Even though tuberculosis of poultry is caused by a specific strain of the tubercle germ, this strain can and does affect other species, especially cattle and pigs. This fact has recently gained particular significance in relation to the Attested Herd Scheme, since cattle so affected, although they may never succumb to the disease, may react to the tuberculin test, the criterion of freedom necessary for Attestation. General farmers are, therefore, well advised to keep their poultry away from cattle and their grazings. In reference to the tuberculin test in poultry, more use might easily be made of this to-day as a reliable means of detecting the diseased members of a flock which to the naked eye may appear quite healthy. There appears no reason why a flock of birds having passed two tuberculin tests, with a period of 60 days between, should not mix with tubercle-free cattle. Once again, Tuberculosis is frequently associated with unhygienic methods of management and the maintenance of a large number of old birds. It is a golden rule to give preference to young birds at the risk of disposing of an occasional good layer of "doubtful age."

Another infectious disease now making its appearance among flocks in Wales is Infectious Laryngo-Tracheitis. As the name infers the main lesions involve the larynx (voice box) and Trachea (windpipe). In most cases the death rate is very heavy and is preceded by a short period of illness. Affected birds show difficulty of breathing—gasping with head extended and mouth open—there may be some discharge from the eyes, the lids of which are often swollen. The disease can reasonably be confused with roup or fowl-pox, and, as in the case of fowl-pox, is caused by a type of an infective agent referred to as a virus. Diseases of such a nature are usually highly infectious but do in a number of cases lend themselves to prophylactic treatment. No satisfactory preventive or curative vaccine has yet been prepared against Laryngo-Tracheitis, and removal of all healthy birds from contact with ailing birds which should be destroyed, is the only practical means of dealing with this condition. The symptoms of fowl-pox are fairly well-known. One readily associates the presence of a "scab" on the wattles and comb and yellowish deposits on the roof of the mouth with this disease. Unlike the former disease, fowl-pox lends itself to a very efficient method of prophylactic vaccination which is now fairly widely known and used.

Like all other animals poultry are subject to parastic infestation which often reaches that stage where the host begins to suffer in varying degrees as a result. The study of disease due to intestinal parasites though intense, has yet far to go in order to give us any real conception of how disease is effected by the parasites and to provide any reliable curative treatment. It can be said without fear of contradiction that no single factor is involved in the production of symptoms by parasites. Foremost among the possible causes one can place nutrition and availability of parasites. Thus, provided, a suitable standard of nutrition is preserved and little opportunity presented for repeated infestation by sound management, the main avenues to the developement of disease can be blocked. Coccidiosis, as is fairly well-known, depends to a great extent upon these two factors particularly the latter fact. There is no doubt that whereas one or even two infestations with coccidial cysts do little or no harm to a well-nourished chick, given the opportunity for repeated infestation even in small numbers in undernourished birds, serious effects will be produced. It is well to remember that the cysts after reaching the ground via the droppings take about 48 hours to become *infective,* so that daily removal of droppings and, if possible, movement on to clean ground every two-days is an excellent preventive measure against further losses. There appears to be no reliable method of medicinal treatment for the cure of coccidiosis for even though it were possible to destroy the parasite, the very nature of the disease with destruction of the bowel lining, which is not easily repaired, is against it. Prevention here again seems to be the rule, and no reliance must be placed upon the failure to find cysts in droppings to rule out definitely the occurrence of disease in cases suspected clinically. While the most dramatic effects of coccidiosis is evident in young chicks, serious loss not essentially always due to death, but by unnecessary culling etc., can result from the effect of coccidiosis in older birds. This condition may often be mistaken from symptoms produced with that condition, badly named, but so widely known and discussed, as Fowl Paralysis.

Courageous individuals, from time to time, make dogmatic assertions regarding the connection between intestinal parasitism and this condition, and while it seems definite that intestinal parasitism of any kind, be it sufficiently severe, may be a predisposing cause, one has ample proof of Fowl Paralysis occurring in birds entirely free of parasites. The popular conception of Fowl Paralysis is by no means the correct one. Experience shows that whereas birds showing symptoms of drooping wings, leg weakness and even certain forms of "bad eyes" may often be cases of true Fowl Paralysis or Lymphomatosis, they are not essentially so and conversely, true lesions of Lymphomatosis can be present as the cause of certain symptoms by no way connected in the lay mind with Fowl Paralysis. The latest work indicates a strong possibility that a "virus" is directly concerned and that the disease or "infection" is contracted in the first few weeks of life although it may not necessarily manifest itself until months later. When perhaps, for some reason or another, its stamina is not up to the strain of the moment (here parastic infection might be a predisposing cause) the bird, "infected" early in life, manifests the fact clinically. There seems no doubt that the disease can be the cause of a very heavy mortality, but there is evidence that suggests, not only that one bird in the flock can be affected, but that a low egg production and poor general condition can be attributed to this cause without any actual deaths occurring.

Space will not permit of any further detail, but attention must be drawn to the possibility of Blackhead in turkeys making its appearance in other types of birds, fowls and game. One welcomes the possibile value of 1 c.c. Carbon Tetrachloride pills, as a curative and preventive treatment, as a freshening breeze among the swelter or arsenical preparations that now stifle the market.

In conclusion one must reiterate and re-emphasise the value of purchasing foundation stock of good quality in the broadest sense, the obtaining of sound advice on the general management of poultry, available through the County Poultry Instructors and the crediting more highly and the purchasing more often of known healthy stocks from local sources, to the encouragement of those breeders, intent on producing a sound article. In the event of losses one must stress, too, the real importance of obtaining a reliable diagnosis, wherever possible; for it may make all the difference between controlling such losses or suffering heavy mortalities, realising a profit or facing a loss and, since the ledger has the last word, this fact must be given the special attention it deserves.

ABSTRACTS, REVIEWS AND BIBLIOGRAPHICAL NOTES.

AGRICULTURAL ECONOMICS.

" The German Fat Plan and its Economic Setting."

BRANDT (Karl), Professor of Agricultural Economics, Food Research Institute, Stanford University, California. (1938). *Food Res. Inst., Fats and Oil Studies.*, No. 6., Sept. 1938.

It is the ill fate of economic systems that their validity can never be tested with the exactitude of the scientist. The doctrine of relativity is never more important than with " fat plans," which must vary with the given natural and social conditions of the same country at different times, and with those of different countries at the same time. The German programme is the only example of complete cartellisation and price control of dairy products and fat by the State ever made on so elaborate a scale. Professor Brandt uses the term "fat " to denote oils as well as fats. The plan is based upon an assumed physiological optimum of food supply, the possibility of using fat in varying proportions with carbohydrate and protein, and of interchanging fats from different sources. Even the immediate future may change these sources, and with it, the fat plan.

> " Dairy cows, meat-cattle, and hogs are on the defensive against fat-yielding plants, marine animals " (the author deals thoroughly with fat from whales and fish) " and even coal and mineral oils." (p. 2).

Dr. Brandt shows clearly that a laisser-faire policy would exert terrific pressure upon the dairy, meat-cattle, and pig industries of Germany, because cheap vegetable oil imports from the tropics would expand rapidly. The cartels for regulating output, imports, prices, and manner of distribution of fat are embraced in the Reich-Food Estate, the compulsory cartel for agriculture and fisheries, which, under public control and management, includes producers, processors and convertors, co-operative associations, and the entire wholesale and retail trade.

> " Its ultimate purpose is to abolish the free price economy . . . and to replace it by a system of strictly controlled supplies, prices and trading. It aims at . . . stable prices for long periods and at equal prices to all producers . . . The only competition left is in the service of waiting on the customer, and in the cleanliness and appearance of personnel and store. Competition is curtailed in . . .wholesale trade as well. Futures trading has been abolished as unethical speculation. The merchant is to be transformed into a distributor who does his duty according to quotas and who may not compete with his fellow merchants for a share of their business."

Dr. Brandt believes that the economic efficiency of the German fat-producing industries has undoubtedly improved, also the quality of milk and butter, and that costs of production and distribution of fluid milk and dairy products have been reduced.

W. F. BRUCK (Cardiff).

ANIMAL NUTRITION

Abstractor:

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Butter Fat: The Relation of Color and Carotene Content of Roughage in the Dairy Ration to the Color, Carotene Content and Vitamin A Activity of.

R. E. Hodgson, J. C. Knott, H. K. Murer, R. R. Graves. *J. Agric. Res.* (1938). 57, 513-28.

The increase in the carotene content of butterfat that followed the inclusion of rations richer in carotene, was not in the same proportion as the increase in the carotene content of the food. The carotene in butterfat accounted for only a small percentage of the total vitamin A activity. It is calculated that the percentage of the vitamin A in the butterfat attributable to carotene ranged from 11.2% when the animals were fed on the hay ration to 13.7% when fed on pasture.

R.O.D.

Calf Meals and Pellets: The use of Yeast in.

P. E. Newman and E. S. Savage. *J. Dairy Sci.* (1938.) 21, 161-167.

The inclusion of dried brewer's yeast and cereal yeast feed in dry mixtures used as milk substitutes for calves resulted in greater growth and body development. The level of 20% dried skim milk could be reduced to 10% without loss of efficiency by the addition of yeast or of yeast and soya bean meal to keep the protein level the same. When two of the calf meal mixtures studied were fed in pellet form there was a decreased consumption and slightly slower growth. R.O.D.

Cellulose Digestion: The Mechanism of—in the Ruminant Organism. IV. Further observations from in vitro Studies of the Behaviour of Rumen Bacteria and their Bearing on the Problem of the Nutritive Value of Cellulose.

H. E. Woodman and R. E. Evans. *J. Agric. Sci.* (1938.) 28, 43-63.

Studies of the behaviour of ceullose-splitting bacteria in artificial media are described. From these it is shown that glucose, pyruvic acid, lactic acid and volatile fatty acids may arise during the breakdown of cellulose by fermentation *in vitro* by rumen bacteria. In what manner these *in vitro* findings may be applied in attempts to explain the value of cellulose to the ruminant, must be left for discussion until the results of work on sheep with rumen fistulas are published. R.O.D.

Chickens: Effect of Percentage of Protein in the Diet on Growth and Feed Utilization of Male.

J. C. Hammond, W. A. Hendricks, H. W. Titus. *p. Agric. Res.* (1938.) 56, 791-810.

It is concluded from these experiments that 21% of protein is near the optimum for growing chickens of all ages when the diet is fed *ad libitum*. After a bird has reached approximately half of its mature weight, the difference in efficiency between a diet containing 21% of protein and one containing 17 or even 15% of protein may be small enough to justify, in the interest of economy, the use of a diet containing the lower percentage of protein. After maximum live weight has been reached, 13% of protein is adequate for the maintenance of male chickens.

R.O.D.

Chickens : The Relation of the Calcium Content of the Ration to Mortality in the.

J. H. PRENTICE. *J. M. of Agric., N. Ireland.* (1938.) 6, 69-74.

In experiments with chickens the addition of supplements of limestone flour to a complete rearing ration impaired the health of the birds and increased the mortality due to coccidiosis. R.O.D.

Cod Liver Oil : The Influence of Hydrogenation and of Yeast in counteracting Injury to Herbivora, and the Influence of Salmon Oil on Milk Fat Secretion.

C. M. MCCAY, H. PAUL, L. A. MAYNARD. *J. Nutrition.* 1938. 15, 367-75.

The lowering of the percentage fat in milk ordinarily produced by feeding cod-liver oil does not occur if the same oil is hydrogenated and then fed at the same rate. An experiment with guinea-pigs showed that this hydrogenated oil did not produce muscle lessions when fed over a period of 60 days. Feeding experiments with salmon oil gave no consistent or conclusive evidence as to its influence on the yield or composition of the milk fat in the case of cows. R.O.D.

Dairy Cows : A Study ot the Effect of Feeding Oils to —and of the Value of the Latin Square Lay-Out in Animal Experimentation.

F. H. GARNER and H. G. SANDERS. *J. Agr. Sci.* (1938.) 28, 428-36.

A description is given of an adaptation of the Latin square lay-out to experiments with dairy cows, which proved very efficient. Palm oil, butter, lard and possibly cotton-seed oil were found to increase butter fat yield, chiefly by raising the butter fat percentage of the milk. Soyabean, linseed and whale oils were without effect. Cod-liver oil definitely decreased butter fat percentage and butter fat yield. R.O.D.

Dairy Cows : The Protein Supply for.

A. C. MCCANDLISH. *West of Scot. Agric. Coll. Res. Bull.* No. 6. Jan., 1938. pp. 36.

The results of trials conducted at the West of Scotland Agric. College are reported. It is suggested that if good home-grown roughages and grain mixture of reasonable variety be fed, the question of the " quality " or " biological value " of the protein becomes of little practical significance. To balance the ordinary roughages the grain mixture should as a rule contain 15-20% digestible crude protein. When feeds rich in protein are relatively cheap the higher level should be fed ; when they are dear the lower level is more economical. R.O.D.

Fowls : On the Influence of Protein on the Fattening of.

E. T. HALNAN. *J. Agric. Sci.* (1938.) 28, 341-5.

Within the limits studied, the efficiency of conversion of food energy to carcase energy is not affected by variation in the protein content of the ration. A food mixture consisting of 5% dried skim milk and 95% Sussex ground oats proved as efficient for fattening fowls as a food mixture consisting of 20% dried skim milk, and 80% Sussex ground oats. The food mixtures used gave satisfactory results in fattening when used in pellet form in a dry state. R.O.D.

Germinated Fodder: Summary of Studies of the—Problem.

J. Sckmidt and J. Kliesch. *Forschungsdienst.* (1938.) 5, 348-53.

Experiments in the feeding of cows and in the fattening of pigs, bullocks and lambs under ordinary agricultural conditions showed no advantages from the use of germinated fodder. The state of health and the egg yield of hens in winter, however, were improved by feeding germinated oats. R.O.D.

Grass Herbage: The Recovery of the Nutrients of—as A.I.V. and as Untreated Silage.

Eire Dept. of Agric. J. (1938.) 35, 2, 171-200.

A report is given of an investigation carried out at the University College, Dublin. The digestibility of Silage made by the A.I.V. method was found to be similar to that made by the ordinary natural fermentation process. Of the food material contained in the original fresh grass, a somewhat greater proportion was recovered in the form of A.I.V. than as untreated silage; the difference, however, was small. R.O.D.

Nutritive Value: The Relation of Cellulose and Lignin Content to the—of Animal Feeds.

E. W. Crampton and L. A. Maynard. *J. Nutrition.* (1938.) 15, 383-95.

It is proposed that, in the analysis of foodstuffs, the two fractions crude fibre and N. free extractives, should be replaced by three fractions, namely, lignin, cellulose and other carbohydrates. The results of digestibility trials with steers and with rabbits indicate that such a procedure applied to the food and faeces gives a better picture of the digestibility of the carbohydrates. The lignin portion appears to be practically non-digested, the " other carbohydrates " highly digestible, the cellulose intermediate in its digestibility. Details are given for carrying out the analysis. R.O.D.

Pasture: Nutritive Value of

XII.—The Influence of Cutting at Monthly Intervals over Nine Seasons on the Quality and Productivity of a Heavy-land Pasture.

H. E. Woodman and R. E. Evans. *J. Agric. Sci.* (1938.) 28. 581-91.

No deterioration of productivity, ascribable to the system of cutting, has been noted on a number of plots submitted to different manurial treatments. It is considered that the results are too restricted in significance to enable generalizations to be made.

XIII.—An inquiry into the Residual Effects of the Intensive use of Sulphate of Ammonia on Pastures. *Ibid.* 592-7.

The artificial stimilation of growth over a period of years by the use of sulphate of ammonia temporarily reduced the inherent vigour of the grasses so that they were unable, when the stimulus was no longer administered, to display as quick growth as grasses which had not been subjected to such stimilation.

XIV.—The Influence on Yield and Composition of a Single Heavy Dressing of Sulphate of Ammonia compared with that of Periodic Small Dressings throughout the Season.

H. E. Woodman, R. E. Evans and P. M. Oosthuizen. *J. Agric. Sci.* (1938.) 28. 598-603.

For efficient utilization of an early heavy dressing of sulphate of ammonia, the weather conditions at this period of the year must be specially favourable, as under unfavourable conditions severe " scorching " of the herbage may occur. On the other hand a light dressing of sulphate of ammonia during February has the advantage of encouraging early growth without risk of " scorching " the herbage. It is concluded that the method of applying sulphate of ammonia in a number of moderate dressings spread over the season is to be preferred to that of applying it all at once in a single heavy dressing during February. R.O.D.

Pig Feeding Experiments. I. Feeding Trials with Excess Separated Milk. II. Feeding Trials with Potatoes. III. Feeding Trials with Sugar Pulp.

Eire Dept. of Agric. J. (1938.) 35, 1, 58-66.

Experiments carried out at the Department's Schools are described. These show (a) that when separated milk is available in large quantities there need be no hesitation in feeding it to fattening pigs up to two or three gallons per head daily, (b) that pigs can consume and assimilate much larger quantities of potatoes than feeders generally would consider safe, (c) that sugar pulp may be used in the ration for fattening pigs to replace up to 15% of the total meals. R.O.D.

Pullets : Observations on the Mineral Metabolism of.

R. H. Common. *J. Agric. Sci.* (1938.) 28. 347-66.

An experiment on pullets combining daily calcium and phosphorus balance determinations with carcass analyses is described. The experiment suggested that pullets may use up to about one-quarter of their body calcium at the outset of laying for purposes of shell formation.
R.O.D.

Rations : The Importance of the Relations between Energy, Protein and Minerals in measuring the nutritive Value of Feeds and—

H. H. Mitchell. *Proc. Amer. Soc. Animal Proc.* December, 1937. 29-42.

Attention is drawn to the associative effects of feeds in digestion and to the fact that the utilization of food energy by growing animals may be greatly impaired by an improper balance among indispensable dietary factors. The effects of protein or mineral deficiencies upon energy utilisation are noted. R.O.D.

Silage : The Composition of Different Kinds of—

A. M. Smith and A. Comrie. *J. Agric. Sci.* (1938.) 28. 203-11.

The chemical composition of different kinds of fresh material and of silage is given. Judging by the appearance and edibility of the material, the silage samples made by the A.I.V. process were almost uniformly good. Their pH values were mainly between 3.5 and 3.8, and they contained less volatile acids and volatile bases than the other silages, and showed the highest proportions of lactic to acetic acid and amino-acids to volatile bases. Two exceptions to this were found in some samples of oats-tare tower silage and grass-molasses silage, with pH values about 4, which contained large amounts of lactic acid and small amounts of volatile bases, and, on the basis of the above-mentioned ratios, were as good as the A.I.V. silage. R.O.D.

Sprouted Grain: The Influence of—on Digestibility.

A. C. McCandlish and J. P. Struthers. *Scottish J. Agric.* (1938.) 21. 141-46.

The replacement of part of the mangels in the ration of bullocks by sprouted maize supplying an equivalent amount of dry matter brought about some improvement in digestibility. This improvement was most marked in the case of the crude and true protein. R.O.D.

Vitamin A.: The—Content of the Colostrum of Dairy Cows.

J. Stewart and J. W. McCullum. *J. Agric. Sci.* (1938.) 28, 428-36.

The vitamin A content of the colostrum of cows kept under the same conditions of dietary and management showed considerable variation from cow to cow. It is suggested that it may be materially affected by the length of the non-lactating period between successive calvings.

R.O.D.

Vitamin A value of Colostrum and Milk of Four Cows Determined by the Single-feeding Method. Vitamin G (Riboflavin) content of Colostrum and Milk of Cows determined biologically.

M. M. Kramer, *et alias*. *J. Agric. Res.* (1938.) 56, 233-7.

The secretions of the first two days were richest in Vitamin A value. By the fourth day of lactation there was a considerable drop in this value, and from the seventh day to the end of the experiment (26 days) it remained much the same.

First day colostrum was richest in vitamin G. The samples of fifth day milk was approximately 50% richer in vitamin G than the later milk from the same cows or the regular herd milk. R.O.D.

Vitamin D: A Comparison of the—Potency of the Stemmy and Leafy Portions of Alfalfa Hay.

G. C. Wallis. *J. Agric. Res.* (1938.) 57, 393-6.

The leaves of good quality alfalfa hay were found to be about six times as potent in Vitamin D as the stems. R.O.D.

Calves: Rearing of—from Birth without Whole Milk.

J. and J. E. Archer, J. R. Bond, G. Dunlop. *Scottish J. Agric.* (1938). 21, 259-67.

The rearing of calves from birth without the use of whole milk is described, separated milk plus cod-liver oil being fed after the calves were 2-4 days old. The growth rates compared favourably with those of animals of the same breed reared on whole milk. The health of all the experimental animals was excellent. R.O.D.

CROPS

Abstractor :

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University College, Bangor.

Silage and Crop Preservation.

S. J. Watson. MacMillan and Co. (1938). Pp. 192.

This book, written mainly for the farmer, deals with the different methods of conserving grass and other fodder crops for use in winter, together with the problems incidental to such processes. A number of useful illustrations is included. The author's practical and scientific experience of this subject makes him well qualified to discuss, not only the processes themselves, but such problems as the handling of the crops and of the final products, their nutritive values, and how to use them to best advantage on the farm. The main purpose of the book is perhaps best explained by the author when he expresses the hope that farmers should become " conservation-minded ", and that they should make better use of fodder crops, thus reducing the requirements of purchased concentrates for winter use. In high protein grass cut in the early stages of growth, they have at their disposal a crop that can now be satisfactorily ensiled, and the reader is told, in a clear way, how to do this ; the recent advances in this subject are embodied in the recommendations.

The other processes, hay making and artificial drying, are dealt with in addition to ensilage, and a comparison is made of the losses incurred, and of the feeding values of the products, etc. The book has an interesting chapter on the management of pastures for producing high-protein grass without deterioration to the sward, and it incorporates some of the important contributions to grassland management made by Martin Jones. The appendix includes precise and clear instructions for the construction of silos, and for making the various kinds of silage. Although this book is not overloaded with detail, it provides the reader with essential practical details about such matters as volume needed for storage, the quantities of molasses or acids required in ensiling, etc.

E.J.R.

GENERAL

Abstractor :

J. Rees, B.A., M.Sc.,
University College, Cardiff.

Practical Lawn Craft.

R. B. Dawson, with a foreword by Professor Sir R. G. Stapledon, C.B.E., M.A., Crosby Lockwood, London. (1939). Pp. 300, 35 figs. Price 15/-.

This is one of the Agricultural and Horticultural Handbooks under the general editorship of H. C. Long. To those who are interested in lawns and such turf, as well as those who have to advise on their problems, this book will fill a long felt want. The author, who is the Director to the Board of Greenkeeping Research at St. Ives, Yorkshire, needs no introduction nor should he apologise for adding this reliable book to the literature on turf upkeep. The author's " aim has been to distinguish supposition from certainty and to provide information based on experiment or well founded practical experience." The results of advisory and research work by the author and his colleagues on various problems under different conditions in this country and abroad are drawn upon in preparing it. As Professor Stapledon says in the foreword, " Mr. Dawson has written a most valuable and exhaustive book...... covering the whole field from golf to cricket, cricket to football, and including polo grounds, race-courses and aerodromes."

The book contains 38 chapters grouped under five sections:—Section I, Chaps. I-IV, Introductory, pp. 15-32; Section II, Chaps. V-VIII, New Lawns, pp. 35-92, deals with the making of lawns from the preparation of the site and soil, and the selection of sods or seeds to the finished product; Section III, Chaps. XIII-XXXII, Maintenance of established turf, pp. 95-218, discusses questions of mowing, fertilizers and chemicals, implements and mechanical operations, watering, weeds, pests, diseases and other difficulties. Section IV, Chaps. XXXIII-XXXVII, Turf for sport and other purposes, pp. 221-256, contains special information for sport grounds, nine pages being devoted to golf course management, while one chapter is devoted to the establishment and upkeep of aerodromes. Section V, Chap. XXXVIII, deals with turf in other countries.

The four appendices include tables of composition of fertilizers and fertilizer mixing, plans and dimensions of sports grounds.

There are three text figures and thirty-two photographic illustrations. These are good and well serve their purpose.

This book is so important and informative that it should be in the hands of everyone who has any interest in any form of lawn, or has to give any advice thereon. J.R.

GRASSLAND

Abstractor:

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Grassland Management for the Practical Farmer.

W. R. PEEL, D.S.O., M.A., F.L.A.S., P.A.S.I., with foreword by Professor Sir R. G. Stapledon, C.B.E., M.A. MacMillan and Co., Ltd., London. (1938). 7/6.

There are few, if any, fields of agricultural research to which so much attention and effort have been directed in these islands during the last twenty years as that of grassland economy. Amongst many findings that have emerged, the significance of management as a dominating factor in governing the composition of swards stands out in relief as a high alp in the new prospect that now emerges before our eyes. Since grassland management is curiously within the farmer's own competence to govern and control, it inevitably follows that the farmer is elevated to the position of sole arbiter of the destiny of the grasslands of the country ; and the charge put upon him is a tremendously heavy one and the position he holds truly exalted. Not only does the personal well-being of the grassland farmer depend on an appreciation of this fact, but the well-being of the State in times of emergency depends largely upon it, too, for the fertility of our grassland regions constitutes to a major degree the latent resources of this land of ours, to be mobilized and mobilized at short notice if need be. It is thus of paramount importance, and indeed an urgent necessity, that whatever precise knowledge that is to-day available to science in this matter, be presented, in terms of farming practice, and at face value to the man actually doing the job.

Colonel Peel proceeds to do it in this volume and he has succeeded admirably well. I know of no other presentation of the findings of scientific investigation into grasslands as applied to farming practice and within the compass of one volume that is up to it. Within its seven chapters we trace a closely knit pattern, woven in clear imagery and phrase, that should be easily understood by the least learned of readers. The theme progresses smoothly, covering all the aspects that are essential and material to the final issue, and whether gleaned from practical experience or from the findings of field and laboratory trials it is presented logically and inevitably.

The secret of this successful presentation lies undoubtedly in the fact that the author is equally at home and well versed in the art of husbandry in the field as in the science of the laboratory.

In his foreword, Professor Stapledon supposes that " there is nobody who has trudged more acres of grassland than has Peel." When one adds further that there are few others, if any, better qualified, both by training and experience, to ruminate on and to predigest for others the mass of data that is available to-day in this extensive field of grassland research, the warrant for high expectation from the author is complete.

To the author the individual elements in a sward are personalities and the sward complex is a society, akin to the sum total of its members, but something more besides. With a few bold strokes, as in chapter I, he limns the individuals, and they become living characters. In chapter II these parade before us not as individuals, but coalescing into societies or associations which many a farmer may already know, ignorant though he may have been before of the individual personalities within them. When he arrives at chapter III, the reader feels he knows the medium he is handling, and chapters III and IV are given to the art of handling ; how, by ploughing, by reseeding and by other means to build up an aristocratic virile sward population—grassland eugenics in a word. Chapter VI covers the very heart of the problem--management in all its aspects according to the design desired in the ultimate pattern and the prolonged maintenance of good swards, once established. Chapter VII is given to mixtures and the laying of land to grass.

I leave mention of chapter V—Conservation of grass --purposely to the last for in the author's own words on page 175, " a greater production of higher quality grass can be obtained on most farms, but unless full use is made of the grass so produced it is idle to consider its production. Artificial drying of grass and the means of storing high quality young grass . . . . . . for use in winter have removed the danger of wasting valuable produce."

Subject as we are in agriculture to the seasonality of growth the whole problem of farming in temperate regions is towards conserving the excess produce of high summer for the needs of winter. That is the bane of the sluggard in farming, but it is also the spur that challenges the progressive one to greater endeavour. Better production and more secure conservation are the dual themes that pervade the whole book before us. The balance between them is clearly seen from the start by the author and admirably pursued to the logical end. R.A.R.

HORTICULTURE

Abstractors :

A. H. HOARE, and N. J. WOOD.
Ministry of Agriculture and Fisheries.

Commercial Apple Production.

T. TURNBULL. *Bulletin No.* 111. of the Ministry of Agriculture and Fisheries. (1938). 56 pp. His Majesty's Stationery Office. Price 1s. 6d. net.

Within the compass of 56 pages, the author, who is one of the Ministry's General Inspectors, has provided a clear and concise account of apple production under commercial conditions in Great Britain. As readers of the Bulletin will not be slow to appreciate, commercial methods differ widely from those commonly practised in private gardens. That there is also some variation in standard commercial practice becomes clear from the short accounts provided of the methods adopted in several important apple-producing areas of England.

The author has given reliable descriptions of the various market varieties and touches carefully upon the important points associated with the planning of commercial orchards, soil management, nutrition, manuring, pruning and the several factors influencing tree performance. Spraying, a subject upon which Mr. Turnbull is rightly regarded as an expert in this country, is but briefly dealt with, but the reader is referred to a special Bulletin No. 5, by the same author, for further information.

A short account of modern methods of apple storage is provided and to complete a useful Bulletin something is said on the subject of finance, from which all prospective growers can learn a little about the capital required to lay down and maintain plantations of apples. The Bulletin, which contains 17 excellent illustrations, serves as a sound and useful introduction to an important branch of commercial horticulture.

A.H.H.

Potatoes.

J. C. WALLACE. Bulletin No. 94 of the Ministry of Agriculture and Fisheries. (1938). 53 pp. His Majesty's Stationery Office. Price 1s. 0d. net.

A special Bulletin on the subject of potatoes has been long anticipated and no one better qualified to undertake its preparation than the Principal of the Kirton Agricultural Institute and Experimental Station, situated in the heart of the Lincolnshire potato growing district, could have been found. Maincrop potatoes are largely grown as a farm crop and occupy a place in the arable rotation in widely distributed districts and on varying types of soil. It is a useful crop to work in with rotations which include short leys and clover crops, so should appeal to those who are interested in mixed farming. It is learned from the Bulletin that all but very heavy clays are capable of producing potatoes for market, but the suitability of the crop for the alluvial, " skirt " and black-fen soils of the Eastern Counties becomes apparent.

In the section dealing with soil preparation details of the various implements employed are given. Several informative pages are devoted to the important subject of " seed " and the part played by virus diseases in bringing about deterioration of seed stocks and the consequent affect on their cropping power is clearly explained. The subject of manuring although a matter on which it is difficult to lay down hard and fast rules, receives adequate and sound treatment by the author, who has conducted much experimental work with this crop on his local soils, and the reader obtains a useful idea of the principles involved.

Much is said on the subject of " blight," the most important epidemic disease attacking the potato crop, and the merits of " wet " versus " dry " methods of control are clearly explained. The various types of machines used for wet-spraying and dusting are described.

Methods of harvesting and storage receive adequate attention and some very useful observations are made on the important question of marketing. The last few pages of the Bulletin are devoted to brief descriptions of standard market varieties and of methods of using up surplus potatoes.

This Bulletin can be recommended to all interested in the subject of potato growing. A.H.H.

Scientific Horticulture. (1939) *Hortl. Education Assn.*, 7., 212.

As the mouthpiece of the Horticultural Education Association, this Journal has filled a gap which long existed in horticultural literature, and its seventh volume now published lives up to the excellent reputation which the previous volumes of a rather youthful publication have already made for themselves. It is full of " meat" for all those who wish to keep themselves up to date in matters horticultural, and, while the bulk of the reading matter deals with fruit-growing problems—natural in view of the fact that the last Annual Conference of the Association was held at the East Malling Fruit Research Station—there are also very interesting articles on the market gardening side. The contributions from local horticultural education officers dealing with commercial methods in their own areas are of particular interest not only to the ordinary reader but also to those concerned with instruction in horticulture in other counties. In addition the article on the horticultural work of the Land Settlement Association throws new light on the activities of that Association in its efforts to establish unemployed men on the land.

Altogether this is an excellent four shillings worth. Copies may be obtained from the Editor, "Scientific Horticulture," South Eastern Agricultural College, Wye, Kent. N.J.W.

LIVE STOCK.

Abstractors :

A. B. BUCHANAN SMITH, M.A., F.Sc., F.R.S.E., Institute of Animal Genetics,
University of Edinburgh,
and
Professor R. G. WHITE, M.Sc., University College, Bangor.

' The Judging of Dairy Cows.'

J. MACKINTOSH. (1938). *J. Brit. Dairy Farmers' Assn.*, 50., 28-45.

An historical review of the relation of conformation as a means for selecting dairy cattle is followed by a survey of scientific work accomplished along these lines. The author concludes that no point of conformation or other feature is of any value whatsoever within a breed as an indication of the fat percentage in the milk of any cow. A few external features, such as size, wedge shape, and the development of udder, milk veins and milk wells, have some value as indicators of quantity of yield, but these features are very inferior to actual records of production.

The escutcheon is no indicator of yield, nor are the skin secretions as to the colour of the fat.

The author maintains that judging by inspection is of importance in the selection of dairy cattle, and recommends competitions, such as those organised at the London Dairy Show, where from 30 to 50 per cent. of the total marks awarded to cows is in respect of their conformation. By this means it is possible to come nearest to a balanced assessment of the dairy qualities of the individual animals. In so far as the true value of a dairy cow can best be judged by her performance over a period of years, greater attention should be given to means whereby "aged merit" can be discovered and recognised. Just as the true merits of a dairy cow cannot be ascertained by inspection alone, neither should they be judged by milk records alone.

He adds that, in view of the importance of known freedom from infectious diseases, admission to competitions should, in the course of time, be limited to those animals which can be certified as free from tuberculosis, contagious abortion and mastitis. A.D.B.S.

Body Measurements of British Breeds of Dairy Cattle.

S. BARTLETT. (1938). *J. Brit. Dairy Farmers' Assn.*, 50 ; 55-69.

At ten consecutive London Dairy Shows (1928-1937) records of type, size and production were collected of the first prizewinners of each breed, and have been annually published in this Journal. Previously a number of measurements had been made of animals exhibited at the four London Dairy Shows held between 1922 and 1925. In the analysis of these measurements in this paper, a comparison is made to Garrard's description of the breeds in 1800.

The ages of the selected animals varied, and this should be allowed for in the consideration of the results. By averaging the body measurements of the prizewinners by inspection, and taking the mean age and live weight into consideration, a table is presented which provides a useful indication of the size and shape of an ideal animal of each breed at the present day. The average for all breeds is 7 years 3½ months for winners on inspection, and 7 years 7 months for milking trial winners. Individual breed averages show wider variation, from 5 years 6 months for the Lincoln Red to 9 years 6 months for the South Devon, in respect of the inspection winners, whereas with the milking trial winners the range is from 6 years 10 months for the Lincoln Red to 8 years 7 months for the South Devon and Kerry breeds.

There is a striking similarity between the body measurements of the inspection winners and the milking trial winners of the same breed, and this makes it impossible to select any outstanding measurement as indicative of inspection or production features.

Dealing with the comparison between the shape of breeds, the author writes :—" The Shorthorns and Lincoln Reds are below the average in length of body, but above average in width of hindquarters ; the Lincoln Reds, however, are slightly smaller in girth of chest. The British Friesians and Blue Albions are somewhat similar in shape to the Shorthorns, but are proportionately smaller in girth of barrel and chest as well as width of hooks. The outstanding features of the South Devons and the Devons are exceptional length of body and large heads. The Devons also possess great width and depth of chest and girth of barrel. The Red Polls are somewhat similar in shape to the Shorthorn, but are slightly deeper, yet more narrow, in body. The Welsh Blacks have large chest measurements, but otherwise conform closely to the average of all breeds. The outstanding feature of the Ayrshires is small chest measurements. The Guernseys and Jerseys are specially narrow in chest and hindquarters, also they possess the smallest bone in the foreleg. Kerries are below average in width of chest and in girth of barrel. Dexters possess exceptionally long and large bodies relative to height, also large heads ; in these respects they somewhat resemble the South Devons."

Dealing with measurements of cattle exhibited from 1922-1925, which were an unselected sample of those exhibited, the figures show clearly that first prizewinners tend to be heavier animals than the average of those exhibited. During the period 1920-1926, the average live weight of all classes exhibited was 1206 lbs., while that of the first prizewinners was 1226 lbs. for inspection and 1220 lbs. for milking trials. During the period 1928-1937 it was much greater, the average of all classes being 1228 lbs., as against first prizewinners on inspection, 1263 lbs., and in milking trials, 1261 lbs.

A final table deals with Garrard's measurements. The Holderness (Shorthorn) cows of 1800 was 59 inches high at the withers, with other measurements correspondingly large. The present-day Shorthorn is usually less than 53 inches in height. An interesting sidelight on the period at which the reduction in size occurred is provided by the measurements of "An improved Shorthorn cow" published by Garrard in 1815, which gives the height at the withers as 56 inches. A.D.B.S.

The Old Story of Type and Production.

L. Copeland. (1938). *J. Dairy Sci.*, 21 : 295-303.

In 1932 the American Jersey Cattle Club made provision for the inspection and rating of Jersey cows and bulls solely on the basis of conformation. The inspections are made by approved judges, and the cattle are given one of six ratings from " Excellent" to "Poor." All animals in the herd must be judged.

The writer examines the type of rating with the actual milk production of the cows. 51 per cent. of all cows classified as "Excellent" were over six years of age, while in the " Good" classification only 27 per cent. were six years of age or older, and only 25 per cent. of the "Fair" cows were over six years old.

Poorer type cows appear to be weeded out of herds, while those of good conformation are retained.

The results in general indicate that there is definitely some relationship between the conformation of a cow and her producing ability, and that both good conformation and high production can be combined in the same animal. The qualities are certainly not inimical to each other. The writer points out, however, that it is a fallacy to suppose that, by breeding solely for production, it will be possible to secure ideal breed type or that by breeding solely for type to secure the ideal in production. Breeders must continue to select and breed with both ideals in mind.

A.D.B.S.

Correlation of Body Measurements of Slaughter Steers with Rate and Efficiency of Gain and with Certain Carcass Characteristics.

W. H. Black, B. Knapp and A. C. Cook. (1938). *HJ. Agri. Rês.*, 56: 465-472.

Fifty steers of beef, dual-purpose and dairy breeding were fed individually before and after weaning, and until they had reached 900 lbs. live weight, when they were slaughtered. Body measurements were taken before slaughter, and a committee, consisting of three men familiar with the American standards, graded the carcases. Correlations have been calculated between the body measurements on the one hand and efficiency of gain, average daily gain, dressing percentage, percentage of fat in carcase, percentage of total edible meat, and slaughter grade respectively. Height at withers, height of floor of chest (a skeletal measurement, really representing the length of leg), depth of chest, and length of body, all give negative correlations, most of which are significant, some being as high as −0.82, with the other factors noted above. The skeletal measurements represented by height at withers and height of floor of chest indicate that taller and leggier animals have less fat and less edible meat than the lower, blockier type. Length of body shows a higher negative correlation of —0.4335 with efficiency of gain, and with rapidity of gain (—0.3224) than does height at withers.

The heart girth correlations are barely significant, the highest being positive in respect of slaughter grade. Width of shoulder and width of chest both show positive correlations, going over + o.6 in both these characters when correlated to slaughter grade. They both show significant positive correlations to efficiency of gain. Width of loin shows a series of non-significant negative correlations of a low order. Likewise, width of hips is without much signficance, except perhaps slightly positive so far as slaughter grade is concerned.

It is concluded that slaughter grade is a better measure of beef type than are any ratios of measurements, and that measurements should not replace, but supplement, reliable slaughter grading. Furthermore, if any ratio is used, corrections will have to be made for difference in fatness, weight, and age, since these do not remain constant for one individual during its life.

A.D.B.S.

Judging Mutton and Lamb Carcases for their Market Suitability.

J. Hammond. (1937). *36th Internat. Conf. Nat. Sheep Breeders' Assn.*

The modern trend in meat requirements is for smaller joints and more tender meat, resulting in a greater demand for lamb and less for mutton. Lamb remains lamb longer in small than in large breeds, and the meat is more fine-grained than in mutton. Relative prices are discussed, and also the changes in the proportions of the body as the sheep grows up. Fullness of the loin is the most valuable part of the body, but does not reach its full maturity until late in life. In the live animal and fresh carcase, this point can be assessed by seeing how far the loin fills up the spread between the thumb and second finger when the loin is grasped in the hand. Legs, also a valuable part of the carcase, should be short in bone and well-filled-out, the space between them being U- rather than V-shaped. In early-maturing breeds changes in proportions are faster than in late-maturing breeds, with the result that in early life they give a much higher proportion of muscle and fat to bone. Lambs of large, late-maturing breeds put much of their food into growth of bone : accordingly, by shortening bone and reducing size, it is possible to obtain a more early-maturing carcase. For this reason the Southdown ram is useful for crossing with late-maturing ewes.

Fat covering and depth of fat over the back are also described, as well as certain other carcase qualities, including colour.

Breeds kept under extensive conditions for wool may be used to yield good lamb carcases, without sacrifice of wool qualities, by mating all cull and second-grade ewes with rams of the Down type, and selling all the offsprings as lambs.

The paper is followed by a discussion. A.D.B.S.

Development of Live Stock in Tanganyika. II. Sheep.

M. H. French. (1937). *Emp. J. Expt. Agric.* Vol. VII. No. 22.

A detailed study of Tanganyika and Persian sheep has been made on the lines of Hammond's well-known work. Crosses between the two breeds were then examined in the same way to discover the possibilities of improvement by such a cross. On the whole the results were disappointing and it is concluded that the obvious need for improvement must be met first by selection within the breed and then by introduction of a small light boned British breed famous for the quality of its mutton. Wool is considered undesirable. To Welsh readers the paper is of special interest because after summing up the characters desired, it is suggested that Welsh Mountain Sheep (black or white) would appear to be the most suitable breed to import. R.G.W.

Prenatal weight changes in Sows : Their effect on the number and Size of new-born Pigs.

H. P. Donald and I. Fleming. *Emp. J. Expt. Agric.* Vol. VI. No. 24.

Emphasis has often been placed on the importance of securing uniform litters of heavy pigs at farrowing, yet there seems to be little information as to how such heavier pigs are to be produced. The investigation reported on was designed to show the effect of the feeding of the sow during pregnancy on the individual weight number and uniformity of litter. The attempt to increase the average weight of pigs at birth by liberal feeding of the sows during pregnancy failed. The results tended to suggest that liberal feeding may increase the number and thus the total weight of the litter, but no clear proof of this was obtained. It should be added that all the sows in the investigations appear to have had adequate rations judged by the fact that all except four out of the forty put on more than 100 lb. live weight increase from mating to after farrowing. R.G.W.

A Normal Growth Curve for Swine.

N. R. ITTNER and E. H. HUGHES. (1938). *J. Hered.*, 29. : 385-6.

Data collected on the weights of pigs at different ages at the University of California Experiment Farm at Davis are based on 5,000 weighings of 450 individuals, 171 before and 286 after weaning. For each week the minimum represents at least 150 weighings.

When plotted, the data show a smooth curve with gradual acceleration to a point where the pigs weighed about 160 pounds : thereafter the curve tends to slope the other way. The curve is not unlike that shown by Russell to exist in the pig (except that it is slightly steeper) and that found by Donaldson and by Hogan for the rat. A.D.B.S.

The Influence of Weaning Weight (8 Weeks) on the Subsequent Development of Pigs.

A. H. BLISSETT and HELEN M. E. DUNCAN. (1938). *Scot. J. Agric.*, 21 : 173-176.

From figures collected from three commercial herds recorded under the auspices of the North of Scotland Pig Recording and Litter Testing Society, consisting of complete results for a full year's farrowing, and representing 80 per cent. of the pigs actually weaned, the following observations are made concerning the influence of weaning weight.

Deaths after weaning were just as numerous among pigs over as under 30 lbs. weight.

The pigs, numbering 616, were divided into six groups according to weight. The greatest mean increase in subsequent growth rate, as measured in pounds live weight gain per day, occurred in pigs weighing from 40 to 45 lbs. at weaning, while the smallest increase took place in the groups of pigs weighing under 30 lbs. at weaning. This result is interpreted as implying that weight at weaning has some effect on the subsequent rate of growth of the pig. Analysing the three farms separately in this respect, certain significant differences were obtained, one farm especially having a greater mean rate of growth per pig per day than the others. Differences are attributed to the different conditions under which the pigs were fed. A.D.B.S.

Growth of Sucking Pigs.

H. P. DONALD. (1938.) *Emp. J. Expt. Agric.*, Vol. VII. No. 25.

Investigations on the growth of sucking pigs have been in progress at the Institute of Animal Genetics, Edinburgh, for some time and abstracts of two earlier papers were given in Vol. XIV of this Journal. The present paper reports an attempt to measure the relative importance of sow and litter. The method employed has been to exchange pigs between pairs of sows farrowing at about the same time, in such a way that each sow reared a litter of which half were her own pigs and half the other sows. From a study of the results obtained, it is concluded that under the conditions of the trial the most important factor in the growth of sucking pigs was the milk production of the sow. R.G.W.

A Report of the Occurrence of Four Cases of Agnathia.

F. Ely, H. B. Morrison and F. E. Hull. (Kentucky Agr. Exp. Sta.) (1938). *J. Dairy Sci.*, 21 : 126-127. (*Abs. Pap. Ann. Meet.*, P.37.)

Agnathia defines a condition where the jaw is absent or deformed. Recently three bull-calves answering to this description have occurred in the herd of the Kentucky Agricultural Experiment Station, while a fourth has appeared in the neighbourhood and is related to the other three.

Anatomical data are presented, and the condition appears to be hereditary. A.D.B.S.

Artificial Insemination.

Reports from various countries show that all over the world the possibilities of artificial insemination are being investigated. The following six papers give results obtained with different kinds of stock under varying conditions :—

Artifical Insemination of Ewes.

C. E. Terrill and E. M. Gildow. (1937). *Proc. Amer. Soc. An. Prod.*, p. 238.

Semen from a Lincoln ram at Dubois, Idaho, was sent 700 miles by air and railway express to Moscow, Idaho. In 1936 sixteen Lincoln ewes were inseminated, three of them becoming pregnant. R.G.W.

Longer Range Paternity in Sheep.

Phillips, Schott and Gildow. (1938.) *J. Hered.*, Vol. 29. No. 12., p. 470.

Semen from rams in Maryland was sent by road, rail and air 2,600 miles to Idaho. Thirty-seven inseminations were made with semen under seventy-two hours old and five lambs were produced. R.G.W.

Preliminary Work on the Artificial Insemination of Live Stock in Palestine.

T. Bell. (1938). *Emp. J. Expt. Agric.*, 6 : 188-192.

Since 1932 artificial insemination has been practised at the Government Stock Farm, Acre, but a test of its practicability was made in August, 1936, and by July, 1937, 226 cows had each been given a single insemination, 51.3 per cent. becoming pregnant, while 172 cows were served in the natural way, with 49.4 per cent. of conception.

The question of using artificial insemination as an economic means for the improvement of livestock in Palestine is discussed. R.G.W.

Artificial Insemination of Cattle and Sheep in Kenya.

J. Anderson (1938) with introductory note by R. Daubeny. *Emp. J. Expt. Agric.*, Vol. VI., No. 23.

This paper outlines the possibilities in areas like East Africa where the introduction and use of improved sires is often limited by questions of disease. A description of the procedure is given and the results of a large number of inseminations are tabulated. With cows, 299 out of 443 were successful (67.5%). In the case of sheep, 3,040 out of 5,742 ewes artificially inseminated (or 61.2%) produced lambs. R.G.W.

Exchange of Bull Semen between England and Holland.

J. Edwards, A. Walton and J. Siebenga (1938). *J. Agri. Sci.*, Vol. XXVIII, Part 3.

Describes an experiment conducted in 1937 to test existing facilities for the transport of bull semen between England and Holland. R.G.W.

Artificial Insemination in Russia.

J. HERED. (1938). Vol. 29. No. 10.

This editorial article summaries a book and a report by N. K. Milovanov. Figures are given showing that artificial insemination is practised more in Russia than in any other country. In 1938, fifteen million ewes and a million and a half cows were to be dealt with. Semen from a Rambouillet ram was used for 13,809 ewes, which produced 14,944 lambs. Twins more than made up for failures. R.G.W.

A New Service-Crate.

J. EDWARDS and A. WALTON (1938). *Emp. J. Expt. Agri.* 6 : 206.

Describes a service-crate and its uses, particularly in connection with artificial insemination.

A plan, one-eighth scale, is included. R.G.W.

The Maternal Effects on Growth and Conformation in Shire Horse-Shetland Pony Crosses.

A. WALTON and J. HAMMOND. (1938). *Proc. Roy. Soc. Lond., Ser.* B. No. 840 : 125 : 311-335.

By means of artificial insemination Shetland pony mares were mated to a Shire stallion and Shire mares were inseminated with sperm from a Shetland stallion. At birth the foals were approximately proportional in weight to the weights of their mothers, and about equal to foals of the pure breeds to which the mothers belonged. The cross foals from the Shire mares were three times the size of the cross foals from the Shetland mares. Maternal regulation of foetal growth was very marked and obscured any genetic differences. After weaning, when the foals were under the same nutritive conditions, genetic differences appeared, those from the Shire mares growing less rapidly than pure Shire foals, and those from the Shetland mares growing more rapidly than pure Shetland. At about 18 months an equilibrium point was reached at which the relative growth rates of the cross-foals and the pure Shetland foals remained constant. At 3 years the difference between the reciprocal crosses is still marked and apparently permanent.

When size differences are eliminated, the differences in the proportions of the animals were not so marked as differences in weight and the influence of nutrition is not so obvious.

In a discussion on the mechanism by which maternal regulation occurs, three possibilities are suggested : (a) maternal regulation of foetal nutrition ; (b) maternal hormonal control ; (c) cytoplasmic inheritance.

In addition to diagrams of growth and weight increase, there are two scale plates of the size and growth of the animals involved. A.D.B.S.

Oestrous and Ovulation in the Mare.

F. F. MCKENZIE and F. N. ANDREWS. (1937). *Proc. Amer. Soc. An. Prod.*, 64-70.

This report deals with 46 mares, Belgian and Thoroughbred. Types of response of the mares are classified, and other facts are given concerning the physiology of reproduction.

The average mare passes out of heat 0.86 day after the corpora lutea are first detected.

The average length of oestrous was 5.54 days, with a range of 1-27 days.

The average length of dioestrous was 15.26 days, with a range of 6-29 days.

The interval between parturition and foal heat ranged from 2 to 12 days, with a mean of 7.25 days.

Ovarian changes are described, and also those of the vagina and uterus. A.D.B.S.

SOILS AND MANURES

Abstractors:

Professor T. W. Fagan, M.A., F.I.C., University College, Aberystwyth,
and
Professor G. W. Robinson, M.A., University College, Bangor.

Palestine, Soils of. Studies in Soil formation and land utilisation in the Mediterranean.

A. Reifenberg, Ph.D., Dipl. Agric. Translated by C. L. Whittles, M.A., Ph.D. 22 × 14. pp. viii × 131. Maps. plts. London: Thos. Murby and Co. (1938.) 14/-.

Palestine claims our interest by its long history, by its sacred associations, and, in these present days, by its troubles, which affect us so closely. But it is also of great interest to the agricultural scientist and economist. It provides rich material for the study of the destruction of natural resources in the past, and of attempts made during recent years to build up again the fertility of ruined land. For the more academic pedologist, Palestine offers exceptional facilities for the study of soil formation under Mediterranean and semi-arid conditions.

Dr. Reifenberg, the eminent pedologist associated with the Hebrew University of Jerusalem, gives an authoritative account of soil formation in Palestine and classifies the soils of the country according to their evolution and characteristics. He includes a valuable discussion of soil formation under Mediterranean climate as compared with that under other climates. He then proceeds to an account of the utilization of soils for citrus-fruit culture under irrigation, with special reference to the possible dangers of irrigation and their avoidance. The concluding chapter is a lucid account of Zionist colonization. Dr. Whittles has produced a very readable translation of an interesting work. G.W.R.

Principles of Soil Science.

Sigmond, Alexius A. J. de. Translated from the Hungarian by Arthur B. Yolland. Translation edited by G. V. Jacks. Foreword by Sir John Russell. 24 × 16. pp. xiv × 362. Pls. incl. chromopl. London: Thomas Murby and Co. (1938.) 22s. 6d.

Professor de Sigmond needs no introduction to those in our country interested in soil science, to whom he is well known as a result of his extensive researches into the reclamation of alkali soils, and as the author of a Monograph on " Hungarian Alkali Soils " and of " General Soil System " both of which are published in English.

The book under review is a translation into English of his Altalanos Talajtan, from which the sections dealing with soil physics and soil microbiology are omitted. It is divided into four parts dealing with soil genetics, agronomy, systematics and cartography.

Part I treats of soil genetics, in which the origin of soils and the different soil-forming factors are fully discussed and the influence of the latter on soil development is thoroughly and lucidly described. The manner in which climate impresses certain characteristics in soil development, as well as the significance of the chemically weathered part of rock-forming minerals in the formation and development of soil character are emphasized.

Part II deals with agronomy and opens with a short chapter on local surveys, in which the value of carrying out a detailed examination of soils in their natural environment is demonstrated.

The assistance such an examination affords in forming a provisional opinion on the soil type when accompanied by the application of simple chemical, physical and biological tests is convincingly shown.

The greater part of this section is taken up with a detailed description of those chemical properties of soils that are essential for understanding and characterizing a soil, and which serve as the foundation of the systematic classification of soils advocated and adopted by the author.

Part III is devoted to soil systematics and forms the major part of the book. After a short general summary of the fundamental principles underlying the best known systems of soil classification, in which the author attaches a certain importance to all these various systems, in that they have led us to regard the soil as the result of the action of the various soil-forming factors, he points out that he has not found one among them, which, while sufficiently comprehensive and based upon the characteristics of the soil, is nevertheless genetic and dynamic in character. For this reason he presents and discusses a comprehensive classification based on the results of leaching experiments. This is the outstanding feature of the book, and although previously published in Hungarian, it has not before been described in detail in an English publication.

Though some readers may not be in agreement with the details of the system, the majority it is felt will agree that it is a considerable advance towards a world classification of soils based on strictly scientific principles.

An impression of how comprehensive the scheme of classification is may be obtained from the fact that twenty-five soil orders are described and each of these is sub-divided into main types. Thus order 11 contains as many as eight main types which comprise the majority of the useful soils.

In Part IV the principles of soil cartography are fully dealt with; various types of soil maps, the laws governing the geographical distribution of soil types and the degree to which the actual distribution of these accord with the general soil system are fully discussed. In this part suggestions are given for the mapping of small areas, and the advantage when offering advice to farmers of practical soil maps which show the deficiency in any one constituent is emphasised. To illustrate this part of the book four excellent plates are appended.

The main theme of the book is the presentation and discussion of the system of soil classification known internationally by the author's name and it will be of particular interest to the soil specialist. The book cannot fail, however, to be of absorbing interest to all agricultural chemists and to many students of geology and geography, for it contains a great deal of information not found in any other work published in this country. T.W.F.

AGRICULTURAL BOOKS, 1938.

The following list, prepared by the staff of the National Library of Wales is a selection of the more important books on the science and practice of agriculture published during the year 1938, together with a few omitted from the List for 1937. The list supplements *The Hand List of Books on Agriculture* issued by the National Library, third edition, 1926, copies of which can be obtained on application to the Librarian, The National Library of Wales, Aberystwyth.

ACKERS, C. P. Practical British forestry . . . Oxford: University Press, 1938. pp. xviii, 388. front., pls. 15s. 0d.

ALLEN, S. W. An Introduction to American forestry. New York: McGraw-Hill, 1938. pp. viii, 402. ill., bibl. $3.50

BEAR, F. E. Theory and practice in the use of fertilizers . . . *2nd ed.* New York: Wiley, 1938. pp. x., 360. front., bibl. .. .. 20s. 0d.

BOYCE, J. S. Forest pathology. New York: McGraw-Hill, 1938. pp. x, 600. ill., diags., bibl. $5.00

BRANTOM, J. H. Vital agriculture in Great Britain, Denmark and the Argentine. Bedford: Rush and Warwick, 1938. pp. 86. front., pls., ill. .. ..

COOPER, W. E. SHEWELL. Up to-date fruit growing. London: English Universities Press, 1938. pp. 296. pls., ill., diags. .. .. 8s. 6d.

CULPIN, C. Farm machinery. London: Crosby Lockwood, 1938. pp. 406. ill. .. .. 18s. 0d.

DE SIGMOND, A. A. J. The Principles of Soil Science . . . Transl . . .by A. B. Yolland. Translation edit. by G. V. Jacks. London: Murby, 1938. pp. xiv., 363. ill., maps. .. .. 22s. 6d.

DOLLAR, J. A. W. Dollar's veterinary surgery . . *3rd ed.* Edit. by J. J. O'Connor. London: Bailière, Tindall and Cox, 1938. pp. x., 990. ill. .. .. 30s. 0d.

FRAZIER, R. W. The Livestock Industry Act, 1937 . . . London: Solicitor's Law Stationery Society, 1938. pp. xvi., 174. .. .. 12s. 6d.

GAIGER, S. H., *and* DAVIES, G. O. Veterinary pathology and bacteriology . . .*2nd ed.* By G. O. Davies. London: Baillière, Tindall and Cox, 1938. pp. x., 712. ill. .. .. 25s. 0d.

HAMMER, B. W. Dairy bacteriology . . . *2nd ed.* New York : Wiley, 1938. pp. xiv, 482. ill., bibl. .. 25s. 0d.

HEALD, F. D. Introduction to plant pathology. New York : McGraw-Hill, 1937. pp. xii, 580, ill., diags., bibl. .. .. 24s. 0d.

HOARE, A. H. Commercial apple growing. London : Martin Hopkinson, 1937. pp. 246. front., pls., bibl. .. .. 10s. 0d.

LARSON, G. W., *and* PUTNEY, F. S. Dairy Cattle feeding and management, *3rd ed.* by H. O. Henderson . . . . New York : Wiley, 1938. pp. xxvi., 558. ill., bibl. .. .. 20s. 0d.

MALOTT, D. W. Problems in agricultural marketing. New York : McGraw-Hill, 1938. pp. xiv, 410. bibl. .. .. $3. 00.

MERCER, S. P. Farm and garden seeds . . .with a section on The Seeds Act, 1920 by A. W. Monro. London : Crosby Lockwood, 1938. pp. 204. pls., diags. .. 10s. 6d.

MOLLER, N. H. A Manual of farm law . . . London : Stevens and Sons, 1938. pp. xliv. 528. .. .. 20s. 0d.

OXFORD, *University. Agricultural Economics Research Institute.* The Distribution of milk : a study of town delivery costs, by J. Cripps. Oxford : The Institute, 1938. pp. 96. .. .. 2s. 6d.

Grass-drying progress : a study of production costs in 1937. By R. N. Dixey and W. F. Darke. Oxford : The Institute, 1938. pp. 62. .. .. .. 2s. 0d.

Milk Investigation Scheme. Costs of milk production in England and Wales. Interim Report No. 2. . . . Oxford : The Institute, 1938. .. 1s. 6d.

P. E. P. (Political and Economic Planning). Report on agricultural Research in Great Britain . . London : P.E.P., 1938. pp. [vi], 146. .. .. .. 8s. 6d.

PATERSON, J. W. Science in agriculture . . . London : Longmans, 1938. pp. viii, 288, ill., diags. .. 6s. 6d.

PEEL, W. R. Grassland management for the practical farmer. London : Macmillan, 1938. pp. xvi, 192, front, pls. .. .. 7s. 6d.

QUARRELL, C. P. Intensive salad production . . London : Crosby Lockwood, 1938. pp. 236, pls., bibl. .. 10s. 6d.

REIFENBERG, A. The Soils of Palestine . . Transl. by G. L. Whittles. London : Murby, 1938. pp. viii, 132. pls., bibl. .. .. 14s. 0d.

ROBINSON, D. H. The New farming. London: Nelson, 1938. pp. 180. front., pls. .. .. .. 2s. 0d.

ROYAL HORTICULTURAL SOCIETY. Ornamental flowering trees and shrubs. Report of the Conference of the . . . Society . . . April 26-29, 1938. Edit. by F. J. Chittenden. London: The Society, 1938. pp. iv, 272, ill. .. .. 10s. 6d.

TROUP, R. S. Forestry and state control. Oxford: Clarendon Press, 1938. pp. viii, 88. .. .. 3s. 6d.

VIRTANEN, A. I. Cattle fodder and human nutrition. Cambridge: University Press, 1938. pp. viii, 108, ill., diags., bibl. .. .. 7s. 6d.

WAKSMAN, S. A. Humus . . *2nd ed. rev.* London: Baillière, Tindall and Cox, 1938. pp. xiv, 526.. bibl. .. .. 30s. 0d.

WATSON, J. A. S., *and* MORE, J. A. Agriculture . . .*4th ed. rev.* Edinburgh: Oliver and Boyd, 1937. pp. x, 822. ill. .. .. 15s. 0d.

WILLCOX, O. W. ABC of agrobiology . . London: Allen and Unwin, 1938. pp. 324. diags... .. .. 12s. 6d.

WRIGHT, C. H. Agricultural analysis . . London: Murby and Co., 1938. pp. x, 344... .. .. .. 16s. 0d.

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ERRATA

Contents, p. 4, and Title, p. 175, for "grain" read "grasses."

THE FEEDING OF DAIRY COWS IN WAR TIME.

By H. E. EVANS, B.Sc.,
University College, Aberystwyth.

During the past winter great difficulty has been experienced in obtaining adequate supplies of purchased concentrate feed. As the outlook for the future is that farmers may have to contend with still further reductions, it becomes evident that home-grown foods will have to assume a more important role in the feeding of all classes of stock. In respect of dairy cows the position is serious owing to their dependence on imported protein for the production of medium to high yields of milk. Studies of milk production during the past winter have shown that the average yield per cow has declined as compared with pre-war winters, and it is to be feared that they will decline still more if the shortage of imported protein becomes acute. Attention has been drawn to the waste which occurs in the feeding of high yielding herds.* Results of feeding for a large number of farms in Wales show that cows giving yields of 500-550 gallons of milk per annum are the most efficient converters of feed into milk. It is only in herds in this yield range that the accepted standard of 3.5 lbs. of balanced concentrate per gallon of milk produced has not been exceeded in recent years when concentrates have been regarded as plentiful and cheap.

It is most important that dairy farmers should realise that in the face of this shortage of feedingstuffs they should utilise what is available in the most efficient manner. Experience indicates that yields will have to drop to the 500-550 gallons level if the optimum of efficient conversion of food into milk is to be maintained.

For the purpose of this study, the records of two dairy farms are examined and tentative suggestions put forward for the feeding of the dairy herds on

(1) Home grown foods alone.
(2) Home grown foods in addition to small quantities of purchased concentrates.

The farms for this purpose will be termed Farms A and B. The area of cropping and the stock carrying capacity of A and B for the year October, 1938, to September, 1939, are shown in Table I.

---

*A. W. Ashby—Feeding of Dairy Cows in War-time. *Home Farmer.* November, 1939.

TABLE I.

Acreage, Land Utilisation and Average Stock Carrying Capacity of Farms A and B.

(October, 1938—September, 1939.)

	Farm A		*Farm B*	
	Acres	*Yield*	*Acres*	*Yield*
		cwts.		
Crops :				
Oats	14.5	261.0		
Mixed Corn	4.5	90.0		
		tons		
Potatoes	2.0	10.0		
Roots	1.5	30.0		
Rape	2.25	—		
Total Arable Crops	24.75			
				tons
Seeds Hay	4.5	9.0	—	—
Meadow Hay	26.75	26.75	20.0	30.0
Total Hay	31.25	35.75	20.0	30.0
Permanent Pasture	69.0	—	42.0	—
Rough Grazing	5.0	—	—	—
	130.0	—	62.0	—
Livestock :	*No.*		*No.*	
Cows	19		23	
Other Cattle	16		17	
	35		40	
Sheep	80		30	
Pigs	5		6	
Poultry	200		200	
Horses	5		3	

The stock-carrying capacities of both A and B are approximately the same in terms of dairy cows. Farm A, however, is the larger of the two and consequently a heavier rental per acre is expected in the case of B. In addition greater expenditure on manures and upkeep would be expected on the latter. These facts are shown in Table II.

Systems of Feeding.

These are considered under (a) Winter feeding October—March, and (b) Summer feeding April—September. Records of foods fed on both farms and the yields of milk produced during the winter period of 182 days are shown in Table III.

TABLE II.

	Farm A	Farm B
	£ s. d.	£ s. d.
Rent per Acre	0 19 2	1 10 0
Operations on Pasture :—		
Cultivations	1 19 0	7 5 0
Upkeep	5 0 0	11 11 6
Manures	23 10 2	57 10 0
Total ..	29 9 2	76 6 6
Cost per acre of Pasture ..	0 7 11	1 16 2

TABLE III.

Cows in herd, Milk output and Quantities of Foods fed Winter period (October—March, 1938-39).

	Farm A	Farm B
	No.	*No.*
Cows in milk	11.35	18.54
Cows suckling	0.69	0.54
Cows dry	6.50	4.30
Total	18.54	23.38
	gallons	*gallons*
Yield per Cow in Herd ..	162.25	326.08
Yield per Cow in Milk ..	262.02	411.21
Total Output of Herd ..	3008.00	7624.00
Purchased Foods :	*cwts.*	*cwts.*
Balanced Ration ..	102	295
Bran	1	1
Total	103	296
Home Grown Foods :		
Hay	205	378½
Straw	133	—
Oats	67	—
Roots	176	—
Grazing Days ..	73	75

The differences between the systems of winter feeding on these two farms are brought out clearly in Table III. It is seen how the feeding of a comparatively larger quantity and variety of home grown bulk foods in relation to a relatively small quantity of concentrated feed tends to limit the yield on Farm A. Farm B on the other hand, by liberal use of concentrated feed in relation to bulk food has a much higher average yield from the herd. It is possible that part of the difference in the performance of the two herds may be ascribed to the pasturage. However, Table III shows that the length of grazing season during the winter is approximately similar on both farms and therefore whatever the difference it occurs in the yielding of the pasturage. Before this problem of feeding dairy cows can be approached logically, and a proper comparison made, the feeding value of the different foods utilised must be reduced to common bases, these being the starch and protein equivalent values of feedingstuffs. Assumptions have to be made, but it is felt that they can be justified in comparative work of this nature. For the purpose of the present study the following values have been adopted :—

(1) Average weight of dairy cows, 10½ cwts.

(2) Maintenance of 10½ cwt. per cow per day in terms of Starch equivalent and Protein equivalent (7lbs. S.E. and 0.7 lbs. P.E.).

For the production of each gallon of milk
2.5 lbs. Starch and 0.6 lbs. Protein are required.

The value of the feedingstuffs consumed by the dairy cows on both farms A and B are shown in Table IV in terms of starch and protein equivalents.

TABLE IV.

Foods fed during winter 1938-39 in terms of Starch and Protein equivalents.

	Farm A		*Farm B*	
	Starch Equivalent in lbs.	*Protein Equivalent in lbs.*	*Starch Equivalent in lbs.*	*Protein Equivalent in lbs.*
Purchased Foods :				
Balanced Ration ..	7,654	1,885	22,137	5,452
Bran	48	11	48	11
Total ..	7,702	1,896	22,185	5,463
Home Grown Foods :				
Hay	8,495	1,056	15,685	1,950
Straw	2,979	149	—	—
Roots	1,380	78	—	—
Oats	4,502	600	—	—
Total ..	17,356	1,883	15,685	1,950
Grand Total ..	25,058	3,779	37,870	7,413

This table shows how Farm B meets its heavier bulk output with a very much heavier feeding of high protein food, as shown in its very high proportion of protein to starch equivalent.

In Table V are shown the requirements of the dairy cows in terms of starch and protein. In addition these theoretical requirements will be compared with the actual feed utilised by the cows in Table IV.

TABLE V.

Theoretical requirements of herds on Farms A and B in terms of Starch and Protein (Winter 1938-39).

		lbs. *S.E.*	*lbs.* *P.E.*		*lbs.* *S.E.*	*lbs.* *P.E.*
Average No. of Cows in Herd	18.54			23.38		
Gallonage of milk produced	3008			7624		
Theoretical maintenance requirement of Cows for 182 days		23620	2362		29913	2991
Theoretical requirement for production		7520	1805		19060	4574
Total theoretical requirement for maintenance and production		31140	4167		48973	7565
Actual Amounts Fed (see Table IV)		25058	3779		37870	7413
Deficiency		6082	388		11103	152
Deficiency per cow in Herd ..		*lbs.* 328	20.9		*lbs.* 475	6.50
Deficiency per gallon of milk produced		2.02	0.13		1.45	0.02

Attention may be drawn to the fact that the actual amount of food fed to both herds in terms of starch and protein does not in either case approximate the theoretical requirements of the two herds.

One would infer from these facts that since, the cows are out on grass during part of that time, they obtain the rest of the nutrient required from the grass they consume. It is also probable that the pasture has contributed far more starch than protein to this process of milk production and that during the winter period we cannot look to pasture to produce the necessary protein balance. Protein from pastures must be collected at some other period in the year and conserved for the winter.

The stage has now been reached where it is possible to see to what extent home grown foods alone can supply the needs of these herds in the process of milk production.

The Feeding of Farm A's Herd on Home Grown Food Alone.

It is probable that Farm A, within certain limits, may be able to produce milk on home grown foods alone, but high protein crops such as beans or peas would have to be introduced in order to balance up the protein deficiency of the more starchy home grown foods. If a system of cropping enables a farmer to grow enough food for the winter feeding of the herd, but at the same time makes too great an inroad to the available grazing during the early spring, then some part of the stock will have to suffer or be dispensed with. In this case the pressure on other stock caused by the changes in uses of land required to feed the cows will depend largely on the previous margins in feed supplies and possibilities of economy.

Attention should be drawn to the difficulty of setting out on paper rations which are at all times suited to a particular herd. The quantities of the various foods fed change with the advance of one season and the decline of the other. Therefore, in a study of this nature only general principles can be laid down and each farmer in practice will have to vary those slightly in accordance with the season and the manner in which the cows are progressing and yielding milk.

Rations suggested for Farm A for the winter period are shown in Table 6. Attempts have been made to relate these rations fed to the acreage of crops and to the stock carrying capacity of the farm. Thus it will be possible to see if any rations composed entirely of home grown foods are practicable even to the extent of not disturbing the pre-war stock carrying capacity of the farm. In so far as Farm A is concerned, these rations make no extra demand on the land used for tillage and it would be very improbable that they effect any change in the normal stocking of the farm. Such rations may have much to recommend them when labour is short, as they enable the farmer to carry on without having resort to any great changes. Beans, kale, cabbage and silage are not very well known in Wales. In some districts these crops may not do quite as well as they should owing to lack of experience in growing such crops. Grass silage is perhaps of higher feeding value than the oat and vetch silage. It is a crop which requires comparatively little in the way of time and labour (except for gathering) or expensive capital outlay. Its feeding value if cut when young and succulent is superb, provided that it is conserved in an effective manner, using one of the approved methods—either AIV acid or molasses.

Feeding of the Dairy Cows on Farm A with limited quantities of Concentrates.

In the case of Farm A the amount of concentrates fed over the

TABLE VI.

Rations Composed of Home Grown Foods suitable for Herd on Farm A for winter (1938-39).

(Based on the production of 162.25 gallons per cow for the period.)

Acreage of Crops required to produce the feeds utilised.

Foods	*Ration 1*		*Ration 2*		*Ration 3*		*Ration 4*		*Ration 5*	
	Acres per Herd	*lbs. per cow per day*	*Acres per Herd*	*lbs. per cow per day*	*Acres per Herd*	*lbs. per cow per day*	*Acres per Herd*	*lbs. per cow per day*	*Acres per Herd*	*lbs. per cow per day*
Grazing	36	—	36	—	36	—	36	—	36	—
Hay	12	8	12	8	12	8	12	8	12	8
Straw	5	5	5	5	5	5	—	—	—	—
Roots	1.5	15	—	—	—	—	—	—	—	—
Kale	—	—	2	20	—	—	—	—	—	—
Cabbage	—	—	—	—	2	25	—	—	—	—
Silage—Oats and Vetch ..	—	—	—	—	—	—	4	20	—	—
Silage (Grass)	—	—	—	—	—	—	—	—	4.5	15
Oats	3.5	2.5	3.5	2.5	3.5	2.5	3.5	2.5	4.5	3
Beans	5	2.5	4	2	4	2	2	1	—	—

whole winter period was approximately 5 cwts. per cow. It may be possible that a system of food rationing will be introduced, but it is hardly likely that the ration of purchased concentrates will be lower than 5 cwts. per cow. It seems likely therefore that this farm should be able to carry on its present system of milk production without being disturbed seriously by the war-time cattle food problem.

Feeding of the Dairy Herd on Farm B on Home Grown Foods

It was shown in Table III how dependent on purchased feed was the dairy herd on this farm. The land is heavily stocked, and had no silage, thus apart from hay all the stock had to be carried with the aid of liberal supplies of purchased concentrates. If this farm were to be forced to feed its dairy cows on home grown foods alone it could never do so and maintain the same yield as the cows were giving during the winter 1938-39.

Consequently Farm B would have to reduce the yield per cow considerably before it would be possible to feed them on home grown foods alone. Furthermore, if there is a possibility of feeding the dairy herd on the farm with the aid of home grown foods alone, there remains another possibility of having to cut down the head of other stock or at least finding some alternative method to sustain them during certain periods of the year.

The problem is to see what system of feeding on home grown foods is least likely to disturb the present stocking of the farm, especially the head of young dairy stock carried; as these compete with the dairy cows for almost all classes of food, but on the other hand are essential as replacements in the herd. In the first instance it is safe to say that while feeding on home grown foods alone the yield per cow for the winter period cannot possibly be maintained at a higher level than 200 gallons. Rations suited to this yield, accompanied by figures to show their demand upon the land, will be shown in Table VII. In Table V it was shown that the pasture contributed a proportion of the starch and protein necessary to the process of milk production on Farm B. It is assumed in building these rations that pasture plays an exactly similar role and therefore its contribution in terms of starch and protein is taken into consideration.

Rations 1 to 4 would make a fairly heavy demand upon the farm for tillage. If the young stock, comprising 16 cattle, were to be fed on home grown foods in addition to the cows, then the tillage would have to be increased by another 30 per cent in order to satisfy the nutritional needs of these cattle. The hay acreage would remain in the region of 20 acres. It seems therefore certain

TABLE VII.

Suggested Rations composed of Home Grown Foods suitable for Herd on Farm B (Winter 1938-39).

(Based on Production of 200 gallons per cow for the period.)

Acreage of Crops required to produce the feeds utilised.

Foods	*Ration 1*		*Ration 2*		*Ration 3*		*Ration 4*		*Ration 5*	
	Acres per Herd	*lbs.* per *cow per day*	*Acres per Herd*	*lbs. per cow per day*	*Acres per Herd*	*lbs. per cow per day*	*Acres per Herd*	*lbs. per cow per day*	*Acrrs per Herd*	*lbs. per cow per day*
Pasture	37.5	—	37.5	—	37.5	—	37.5	—	37.5	—
Hay	14.8	12	14.8	12	14.8	12	14.8	12	14.8	12
Straw	—	8	—	6	—	6	—	—	—	—
Mangolds and Swedes ..	1.3	20	—	—	—	—	—	—	—	—
Kale	—	—	1.5	20	—	—	—	—	—	—
Cabbage	—	—	—	—	1.5	25	—	—	—	—
Silage (Oats and Vetch) ..	—	—	—	—	—	—	4.0	20	—	—
Silage (Grass)	—	—	—	—	—	—	—	—	6.0	13
Oats	7.5	4	5.8	3	5.8	3	3.75	2	3.75	2
Beans	6.3	3	4.2	2	4.2	2	4.2	2	—	—

that under such circumstances the farm could not maintain the young stock it carries today were the herd to remain in its present numbers.

One of the most critical periods regarding the grazing is the early spring and it is then that the stock carrying capacity of the farm is tested to its utmost. It is very doubtful if rations 1 to 4 would enable the cows alone to have enough grazing at this period because the requirement of tillage for winter feed reduces the land available for grazing and hay to a very low level. There would certainly be no grazing available for the young stock at this period unless the productivity of the pasture had been raised to a level considerably higher than pre-war. It seems therefore pretty certain that the head of young dairy cattle would have to be cut down owing to the extent they would compete with the cows for food and pasture. In the case of Ration 5, however, there seems to be a distinct possibility that such harsh changes would not have to be brought about were the system of feeding to be run on these lines. Grass silage would enable the land to be used for grazing at certain periods, and would not seriously hamper the system of farming already practised. With this form of feeding cattle there are distinct possibilities provided that every effort is directed to maintain the pastures and the aftermath in the best of conditions and at its maximum productivity.

The Feeding of the Herd on Farm B with Home Grown Foods supplemented with small quantities of Purchased Concentrates.

During the winter period 1938-39, Farm B consumed 296 cwts. of concentrate feed or 12.7 cwts. per cow, or, alternatively, 7.8 lbs. per cow per day. During the coming winter, 1940-41, conditions can be visualised whereby the quantity of purchased concentrates available might be one-half of this quantity. Under such circumstances it would be possible to raise the average yield per cow from 200, as previously assumed, to 250 gallons per cow for the winter period.

Rations suitable (excluding pasture) to meet this yield and at the same time enabling Farm B to maintain its normal stocking are suggested in Table VIII.

It is evident from the nature of these rations that their demand upon land will not appreciably affect the stock carrying capacity of the farm.

Ration 2, in addition, enables the home grown cereal crops which have to be grown under the direction of the War Agricultural Executive Committee to be given to the young dairy stock, while the cows would be maintained mainly on grass products (hay and

TABLE VIII.

Ration suggested to enable Herd on Farm B to produce an average of 250 gallons per cow for Winter Period October—March.

Foods	*Ration 1* *Lbs. per cow per day*	*Ration 2* *Lbs. per cow per day*
Hay	12	12
Straw	4	—
Grass Silage	—	9
Kale	20	—
Concentrates	3.75	3.75
Oats	2	—

silage) as before. Again stress has to be laid on the necessity of raising the productivity of the grassland in order to obtain this result.

Summer Feeding

In the case of summer feeding we are at a disadvantage to know the exact amount of nutrients which pasturage contributed to milk production, therefore in the case of both Farm A and Farm B, we cannot attempt to put forward any tentative suggestions for rationing. It is natural that during April winter feeding will have to be carried on as usual unless the weather is very open and there is good grazing. However, from May onwards to September, the grazing will have to carry the cows and they will have to be content with such concentrated feeds as may be available. It is possible that with good management yields of 300 gallons per cow should be maintained during the summer period. Naturally the milk yield will adjust itself to the quantity and the quality of the grazing. Whatever concentrated feed is on hand would be used when most required, possibly mostly during the month of July when the first flush of grass tends to die off.

Such crops as rye, oats, and vetches grown for forage and cut green will come in rotation around the time of pasture shortage and tide the cows over relatively poor grazing.

In addition winter rye, winter oats and vetches could be grown in order to give cows green and succulent food in the early spring and this would certainly be of great value if the grass is not growing according to schedule.

Too much stress cannot be laid on the value of grass as a food under all circumstances. In difficult times such as we are experiencing, it is imperative that every effort should be done to utilise the grassland to the best possible advantage. Efficient management in the form of manuring and cultivation should be undertaken to stimulate maximum growth of grass. If it tends to run before the stock it should be conserved in the form of silage. Silos for the purpose are easy and cheap to obtain.

With the feeding of greater quantities of home grown food, as is inevitable to happen during the winter, yields are practically certain to decline. Great care should be taken to keep the cows as healthy as possible under such circumstances in order that they will give of their best. Too much attention cannot be paid to herd hygiene as this will keep the cows from temporary barrenness, thus increasing their useful milking life. Calvings should be arranged at fairly regular intervals so that there is not a great predominance of spring calves and summer milk which is undesirable from the national standpoint.

Conclusions

Cows will yield milk in fair quantities on home grown foods alone. These have to be chosen very carefully, however, if they are not to disturb the existing systems of cropping and the stock carrying capacity of the farm to any appreciable extent, especially in the case of grass dairy farms.

The value of grass silage conserved in the young and succulent stage is not fully appreciated. It is equal to a highly concentrated feed if properly made.

Greater efforts are necessary to increase the productivity of grass, the cheap natural food, with the aid of manures and better cultivation of the grassland.

Cows cannot utilise food to the best advantage unless they are in good health and managed properly. Good care of the cows is therefore the key to efficient milk production.

THE LABOUR REQUIREMENTS OF THE PLOUGHING-UP CAMPAIGN IN WALES.

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As a contribution to the national war effort farmers in Wales were asked to plough up 180,000 acres of pasture and, where conditions permitted, sow the land with cereals during 1939-40. This task, which increases the arable area by nearly 34 per cent and the tillage area by 62 per cent, aroused fears of a serious shortage of farm labour, especially during the coming corn harvest. In June, 1939, the total complement of labour amounted to about 78,300 persons or 29 to each 1,000 acres of cultivated crops and grass. Since then there have been losses; some of the younger workers have been called up for military service, while in South Wales, in Flintshire and Denbighshire there has been some movement of workers from farms to newly established industrial concerns associated with war operations or the production of war material. Apart from losses due to military recruitment, the main reductions have occurred amongst workers who are only casually employed in agriculture. But there is need to replace those who have left the industry and to provide for the extra work arising from the ploughing campaign.

The extent of the labour force in each of the counties varies between 21 and 38 persons for each 1,000 acres of cultivated crops and grass. There are important differences in the effective utilisation of the available supply of farm labour in each of the counties, but these are due chiefly to differences in the size of the farming units, to topography and systems of farming. The ratio of labour to land is low in counties where store cattle and sheep predominate. In Flintshire the ratio is particularly high but a considerable part of farming activitiy is associated with milk production. Size of farms is a factor which frequently has a great influence upon the ratio of labour to cultivated land. In some districts the supply of family labour on the smaller farms is much greater than the requirements and it is not always possible for the surplus labour to find alternative employment on neighbouring farms. An extension of the area under tillage crops will therefore enable some farmers to make better use of their present complement of labour. In other instances where there previously existed some shortage, it will be necessary to make provision for the supply of more workers.

The Extent of the Task.

The total addition to the land under tillage crops is appreciably greater than that requested by the Government. The following table, however, shows the importance of the quota in each of the counties.

TABLE I.

County Allocations of Acreage to be Ploughed up in 1939-40.

Wales.

	Ploughing-up Quotas	*Per cent of*			
		Total Cultivated Area	*Permanent Pasture*	*Arable*	*Previous Annual Crops*
	1,000 Acres	%	%	%	%
Anglesey	10	7.3	9.5	30.7	68.3
Brecon	10	5.9	7.3	30.9	59.8
Cardigan	15	6.3	9.1	20.5	33.4
Carmarthen	30	7.5	8.4	75.8	120.6
Caernarvon	10	6.7	8.8	27.8	70.0
Denbigh	20	8.1	10.7	33.4	65.1
Flint	10	8.4	10.3	45.8	85.7
Glamorgan	15	7.0	8.3	46.9	80.7
Merioneth	5	4.1	5.1	22.1	47.0
Monmouth	15	7.2	8.0	70.6	101.0
Montgomery	15	5.8	7.4	28.4	53.6
Pembroke	20	7.0	9.5	26.4	45.3
Radnor	5	3.3	4.4	13.4	27.9
Wales and Monmouth	180	6.7	8.3	33.5	61.7

The ploughing quota in each of the counties reduces pastures and meadowland by amounts varying between 5 and 11 per cent. In Carmarthenshire and Monmouthshire farmers had previously ploughed only a very small proportion of their land, and the quota now increases the arable area by more than 70 per cent and the tillage area by more than 100 per cent. In the other counties the quotas increase the arable area by less than 50 per cent and in Radnorshire the increase is less than 14 per cent.

In 1939 less than 11 per cent of the cultivated land in Wales was under tillage crops and only in six counties did the land used for annual crops exceed 10 per cent of the total. The quota for each county varies between 5,000 acres for Merionethshire and 30,000 for Carmarthenshire, but the larger quota is only 8.4 per cent of the total permanent grass in the latter county. Farmers in Denbighshire and Flintshire have a relatively greater task in that they had to plough up a greater proportion of pasture land.

With the addition of 180,000 acres the tillage area will account for 17.5 per cent of the cultivated land. Considered in its proper perspective the quota does not involve any need for large increases in farm personnel. In general it amounts to about six acres per holding; those for the individual counties ranging from three to seven acres.

TABLE II.

Additional Ploughing Quota per Farm and Total Ploughing task per Pair of Horses.

(Based on 1939 Statistics.)

	Holdings over 20 acres		*Agricultural Horses*	
County	*No.*	*Quota per Holding (Acres)*	*No.*	*Quota plus tillage per pair of horses (Acres)*
Anglesey	1,728	5.8	3,119	15.8
Brecon	1,815	5.5	4,385	12.2
Cardigan	2,957	5.1	7,913	15.1
Carmarthen	5,281	5.7	11,787	9.3
Caernarvon	1,979	5.1	3,607	13.5
Denbigh	3,010	6.6	5,647	18.0
Flint	1,460	6.8	2,729	15.9
Glamorgan	2,743	5.5	7,111	9.4
Merioneth	1,692	3.0	2,553	12.3
Monmouth	2,257	6.7	5,533	10.8
Montgomery	2,982	5.0	6,790	12.7
Pembroke	3,360	6.0	7,732	16.6
Radnor	1,418	3.5	3,587	12.8
Wales and Monmouth	32,682	5.5	72,493	13.0

All ploughing during last autumn and this spring amounted to about 13 acres for each pair of work-horses. In Carmarthenshire it was less than 10, while in Denbighshire it was as high as 18 acres.

More than 50 per cent of the occupiers of land have ploughed up plots of pasture of less than five acres and in some counties the proportion of these small plots may be appreciably higher. The number of farmers who have ploughed up more than 20 acres of pasture will be considerably less than 10 per cent of the total and in one or two counties the proportion may be less than five per cent. About one half of the extra tillage land will consist of small plots ranging up to 10 acres and less than one-quarter will be in plots of more than 20 acres.

Forty-four per cent of the recorded holdings in Wales have less than 20 acres and only nine per cent have more than 150 acres of cultivated land. Although size of holding does not show the exact size of farms, it does indicate the smallness of the unit of farming. From the following table it will be seen that holdings of 100 acres or more account for less than half the total cultivated land while those of more than 150 acres account for less than one quarter of the total.

TABLE III.

Estimated Percentage of Cultivated Land in Large Holdings.

County	*All Holdings of* 100 *acres or over*	*All Holdings of* 150 *acres or over*
	%	%
Anglesey	42.4	19.5
Brecon	56.7	29.9
Cardigan	41.3	16.0
Carmarthen	38.4	13.8
Caernarvon	39.4	20.1
Denbigh	44.9	23.5
Flint	44.1	23.6
Glamorgan	42.2	21.0
Merioneth	37.0	18.0
Monmouth	56.9	32.9
Montgomery	49.6	25.9
Pembroke	49.9	28.1
Radnor	65.3	42.0
Wales and Monmouth	46.2	23.7

There are only three counties in which holdings of 150 acres or over account for 30 per cent or more of the cultivated land, while in four counties these larger holdings contain less than 20 per cent of the total cultivated land. Only in three counties do the holdings over 100 acres contain more than 50 per cent of the cultivated crops and grass. It follows, therefore, that a large part of the pastures ploughed up will be in the smaller farms operated mainly by family labour.

Few farmers with less than 50 acres will have added 10 acres to their tillage land and it is unlikely that any of them will employ more regular workers for the summer months. Although a large proportion of farmers occupying between 50 and 100 acres of land will have increased their tillage land by 10 acres or more they are not likely to need any extra workers until the corn harvest. Possibly only a small proportion of these farmers will engage more hired men and many of them will accomplish the extra work by mutually assisting each other. It is doubtful whether 75 per cent of the occupiers of farms of between 100 and 150 acres would engage an additional worker for the five months June to October. But farmers who have ploughed up more than 20 acres of pasture may find it necessary to employ more regular workers for the summer months.

Supply of Labour.

In 1931 farmers formed 45 per cent and their relatives 15 per cent of the total regular labour force; hired regular workers amounting to only 40 per cent of the total. In Carmarthenshire hired regular workers formed less than one-third of the total complement of farm labour and in no county was the proportion as high as 50 per cent. In every county farmers represented more than 40 per cent while the proportion of other family labour in each of the counties varied between 10 and 22 per cent.

Last year there were 36,544 regular workers and 5,958 casual workers employed on farms in Wales while farmers numbered about 39,000. The number of casuals employed in June was less than one-sixth of the regular workers. Some additional casual workers may have been employed during the next three months, but in the busiest periods of the year the total number of casuals would be less than 10 per cent of the total intra-seasonal supply of all labour. The total work done by casual workers in any year amounts to no more than five per cent of the total.

If the quota area were cropped with the same crops as the ordinary tillage area in an average year, and it were considered without any possible reduction in grassland or stock, it would add 9 per cent, or the work of 7,000 persons, to the pre-war task on Welsh farms. But these figures do not take account of economies in the use of labour which may arise from the increased use of tractors and machinery, nor of possible improvements which may be obtained in the use of the existing supply of labour. The actual number of workers required above those employed last year will be very much less than this gross estimate.

Deductions in the acreage under grass and hay may cause some farmers to reduce the number of livestock carried on their farms, but in most cases they will try to maintain their normal complement of livestock. The provision of cheap lime and basic slag under the Land Fertility Scheme has enabled farmers to improve the stock carrying capacity of their pastures. Any changes which are likely to occur in numbers of livestock will chiefly affect store cattle and sheep and will not release any large number of workers.

Much of the extra work arising from the ploughing quota could be done by improvements in the utilisation of the existing supply of labour. There are a number of unavoidable circumstances responsible for differences in the comparative utilisation of labour. There are districts where the family labour on the smaller farms is greater than the real requirements and it would be an advantage to those farmers and their families to have more work which offers prospects of a fair return per hour of labour. A simple comparative measurement of labour requirements for the crops and livestock of each county shows that in five counties the utilisation of the present labour force is less economical while in the remaining eight counties it is better than the average for Wales.

If the supply of labour in Caernarvonshire were reduced by 19 per cent the comparative task for each worker would then be no greater than the average for Wales. In Radnorshire, on the other hand, it would be necessary to increase the labour force by 17 per cent in order to reduce the task of each worker to make quantities comparable to the average for Wales. These measurements show that farmers should consider possibilities of using the existing supply of labour to better advantage. Unemployment amongst workers in Wales insured under the agricultural scheme and has amounted to between 10 and 11 per cent in each of the last two years as compared with between three and five per cent for Great Britain. In one of the Welsh counties 30 per cent of the insured workers were out of work during last December and in March of this year 8.5 per cent of these insured workers in Wales were out of work. Although other workers are insured under this scheme, 75 per cent of the whole are agricultural workers and many of the unemployed are agriculturists. Under normal circumstances a further loss of farm workers in some districts could have occurred without any serious consequences to farming.

Additional Labour Requirements.

With the same complement of labour as that used in 1939 the tillage area this year would be 6 acres per person as compared with 3.7 acres last year. The increases in tillage in each of the counties vary from 1.4 to 2.9 acres per persons. Estimates of the number of extra workers both for regular and for seasonal employment need to take account only of those cases where the additional

TABLE IV.

Utilisation of Labour on Welsh Farms.

County	*Crops and Livestock per person*										
	No. of Persons	*Total Cultiv. Area*	*Tillage*	*Grazing*	*Hay*	*Horses*	*Dairy Cows*	*Other Cattle*	*Sheep*	*Pigs*	*Poultry*
	No.	*Acres*	*Acres*	*Acres*	*Acres*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*
Anglesey	4,409	31.14	3.32	20.02	7.80	1.30	2.51	8.84	40.57	2.40	43.73
Brecon	4,089	41.26	4.09	27.07	10.10	2.41	3.20	6.67	135.66	1.93	48.79
Cardigan	7,343	32.35	6.12	18.18	8.05	1.89	3.11	5.96	44.61	2.36	56.08
Carmarthen	10,612	37.49	2.34	24.48	10.67	1.76	5.19	6.74	32.85	1.62	58.48
Caernarvon	5,438	27.52	2.63	15.61	9.28	1.08	2.95	6.46	63.83	1.97	46.91
Denbigh	7,609	32.39	4.04	20.16	8.19	1.17	3.72	7.63	68.89	3.28	46.74
Flint	4,504	26.35	2.59	16.53	7.23	0.93	4.97	6.78	34.67	4.49	63.78
Glamorgan	6,928	30.76	2.68	16.73	11.35	1.75	3.70	6.27	52.46	2.92	50.11
Merioneth	3,625	33.31	2.94	19.67	10.70	1.02	2.70	7.40	122.06	1.50	28.40
Monmouth	5,524	37.97	2.69	22.24	13.04	1.72	3.22	7.45	51.37	3.42	84.70
Montgomery	7,214	35.58	3.88	22.10	9.60	1.60	3.11	8.37	82.42	3.30	74.52
Pembroke	7,838	36.54	5.63	20.73	10.18	1.64	4.13	8.55	21.13	3.26	53.89
Radnor	3,148	48,30	5.68	31.55	11.07	2.50	2.84	8.11	112.53	1.35	59.77
Wales and Monmouth	78,281	34.42	3.73	20.90	9.79	1.60	3.65	7.27	59.27	2.65	56.05

tillage land per farm exceeds five acres. Few who have ploughed between five and ten acres of pasture will require additional regular workers and only a very small proportion will require extra casual workers. Most of the demand for labour will be confined to farmers who have added more than fifteen acres to the area under annual crops. The maximum possible additional requirement of farm labour for the Principality amounts to about 9 per cent ; in Radnorshire and Merionethshire it is as low as 5—6 per cent, while in the other counties it varies between 8 and 11 per cent.

TABLE V.

Supply of Labour in Relation to the Ploughing up Schemes.

County	*Persons per 1,000 acres Total Cultivated Area*	*Index of Efficiency of Organisation in use of Labour*		*Estimated gross addition to Labour Task*	
		1939 Labour and Cropping	*1939 Labour, 1940 Cropping*	*Per cent*	*No.*
Anglesey	32	84	85	10.8	476
Brecon	24	112	111	8.7	356
Cardigan	31	100	99	8.1	596
Carmarthen	27	103	104	11.0	1,161
Caernarvon......	36	81	81	9.0	488
Denbigh	31	101	103	10.3	783
Flint	38	101	101	8.7	392
Glamorgan	33	93	93	9.3	642
Merioneth	30	89	87	6.1	222
Monmouth	26	99	100	10.9	603
Montgomery	28	106	104	7.8	564
Pembroke	27	110	110	9.2	720
Radnor	21	117	113	5.4	170
Wales and Monmouth	29	100	100	9.2	7,173

These gross estimates of extra needs vary from 170 workers for Radnorshire to nearly 1,200 for Carmarthenshire. But the actual number of workers who are likely to be placed on farms additional to those employed during last summer will be appreciably less than these gross estimates. Labour requirements of livestock during this summer will not be greater than in previous years and may be less. But the important factor which needs to be taken into consideration is the increasing use which is being made of tractors. Each County War Agricultural Executive Committee has a number of tractors at its disposal and there has been a large increase in the number of farmer-owned tractors. Last summer there were just over 1,600 tractors on farms in Wales, capable of being used for field work, that was one tractor for every 1,665 acres of crops and grass, or one for every 180 acres of tillage land. The number of government tractors now on farms is 270 (March, 1940), and they constitute an increase of 16 per cent on the number of tractors previously recorded. It would be necessary to increase the number by more than 60 per cent in order to have the same ratio of tractors to tillage land as in 1939. It is unlikely that this increase has occurred but the extra tractors now owned by farmers ,by contractors and by County War Agricultural Committees will greatly assist farmers with the field operations during this summer. The increased number of tractors and implements enabled the autumn and spring work to be done without any special difficulties.

Except in areas where local competition for labour has been acute there will be no need to supplement the present complement of labour until the commencement of the corn harvest. The acreage of meadowland likely to be closed this season for hay will almost certainly be 15 per cent less than in previous years. With normal weather conditions a much smaller labour force could, with the increased use of tractors and harvesting machinery, gather in the hay before the corn harvest begins.

Increases in the area under root crops are not likely to be of sufficient importance to cause any appreciably greater demand for labour. Few farmers in Wales are increasing the areas planted with potatoes except in South Pembrokeshire and in Flintshire and in general the normal labour force will be able to cope with the harvesting of this crop. There will be increases in the area under mangolds, swedes and turnips and the demands upon the farm labour for singling and weeding will be greater. But the smaller labour requirements for the hay harvest should offset any extra labour required for roots.

Additional labour may be required for the corn harvest, but something like 50 per cent of the extra corn will be harvested by occupiers of smaller farms without the need for any increase in the supply of labour. An extension of the common practice of neighbouring farmers pooling their labour resources for the hay and corn harvest will enable a considerable number of larger farmers to cope with the extra work with the normal complement of labour. It is unlikely that those farmers in need of additional labour will have a total of 100,000 acres of cereals more than in previous years and it is therefore improbable that the requirement of harvest labour will reach a figure 10 per cent greater than those of previous years and the additional number used during August and September may not exceed 5,000 persons.

Conclusions.

Earlier county estimates of additional labour requirements are now known to have been too high and during recent months there have been few complaints of general shortage. The weather conditions of the spring enabled farmers to accomplish seasonal tasks without any hindrances and many acres of hay crops have already been harvested* without the help of additional supply of labour.

In Wales there is no urgent demand for more labour and some localised offers of the free services of members of the armed forces have found little response. Likewise there has so far been very little demand from farmers for the use of students and pupils from colleges and schools, nor have farmers felt any great need to seek the assistance of members of the Women's Land Army.

A further indication of the absence of serious need for more farm labour is shown by the difficulties which Unemployment Exchanges are experiencing in placing agricultural workers registered as unemployed. Under an order which became effective on June 10th, farm workers can no longer obtain employment in other industries, while those who have previously left agriculture will have to return to the land as soon as their present employment ceases. The insistence that ex-farm-workers shall return to agriculture will only be justified if their labour is required by farmers. Unless therefore farmers register with the Unemployment Exchanges any additional needs for labour, unemployed farm-workers may experience an unnecessarily long period without work.

Farmers have willingly accepted increased responsibilities and up to the middle of May the ploughed up grass-land in Wales had exceeded the quota by nearly 37,000 acres. Additional seasonal tasks have been accomplished without extra manual labour and in many cases with less labour than was used for similar tasks in previous years. Need for additional labour will occur during August and September, but farmers will manage the farm tasks after the harvest with their present complement of regular workers.

The additional labour requirements during the coming harvest will be mainly confined to farms where the larger tracts of pasture land have been ploughed and sown with arable crops. The extra needs on these farms will be most effectively satisfied by the formation of small teams of workers able to do harvesting tasks. By organising harvesting operations in the manner common in East Anglia, the cereal crops will be quickly harvested and with the minimum of additional labour. By organised team-work full use can be made of labour now on offer even though much of it has had little or no previous experience of farm tasks.

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*June 30, 1940.

THE CONSUMPTION OF GRAIN AND GRAIN PRODUCTS BY POULTRY FLOCKS.

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There is almost complete absence of information on the efficiency with which laying flocks convert foodstuffs into eggs and such information as is available does not relate to commercial flocks. The main difficulty in obtaining reliable information is due to the fact that almost every poultry enterprise is, in a smaller or greater degree, involved in the production of both poultry and eggs. The *gross* food requirement of poultry flocks as measured per laying hen and per dozen eggs will depend upon

(a) the necessary rate of flock renewal owing to (i) culling, (ii) death-rate (or the combination of the two) ;
(b) the policy of flock renewal (i) hatching and (or) rearing or (ii) purchasing stock at advanced stages of growth ;
(c) the converting capacity of the hens ;
(d) the general care and management of the flock.

As regards (a) each bird which dies represents a loss of flesh and increases the requirement of feed per dozen eggs. Each bird culled early in life requires the rearing of another bird, possibly two because of the sex ratio, and this raises the ratio of flesh to egg production and the food requirement per laying bird.

As regards (b), where breeding, hatching and rearing are done, the initial process of breeding adds the cocks to the stock list and both pullets and cockerels or pullets only may be reared. Wide variations in gross food requirement will occur with these conditions.

Net food requirements per laying hen or per dozen eggs (i.e. gross supply, less supply used for flesh production) will very largely depend upon

(a) the converting capacities of hens ;
(b) the general care and management of flocks ;

and as regards (b) the death-rate and (or) the rate of culling will be important.

In some cases, as when nature pullets are purchased for building up and maintaining laying flocks, the receipts from sales of poultry form an insignificant portion of the gross cash receipts while in other cases sales of poultry may constitute as much as 60 per cent of gross receipts. In general, however, sales of eggs will constitute between 70 and 90 per cent and poultry between 30 and 10 per cent of gross receipts. The average physical output from reasonably well managed flocks may be estimated at 140 eggs and 5 to 6 lbs. of poultry (live-weight) per laying hen.

In order to place records of feed consumption in relation to egg production for individual flocks on a comparable basis, it is necessary in each case to discount food consumed for the purpose of producing poultry for slaughter. Separate records of food consumed by growing stock are not generally available so the recorded food consumption per bird and per dozen eggs contained in the following summary relates to total food consumed by all stock.

TABLE I.

Gross Food Consumption.

Per Laying Bird		*Per Dozen Eggs*	
Range. lbs. per Bird	*No. of cases*	*Range. lbs. per dozen Eggs*	*No. of cases*
140 and over	20	Over 16	7
130 and under 140	3	14 and under 16	7
120 " " 130	6	12 " " 14	9
110 " " 120	7	10 " " 12	10
100 " " 110	8	8 " " 10	14
90 " " 100	5	6 " " 8	7
Under 90	7	Under 6	2
	56		56

It will be seen that for a very large number of flocks the gross food consumption exceeded 140 lbs. per laying bird and in general varied between 8 and 14 lbs. per dozen eggs produced.

There is no means of knowing exactly what deductions should be made in order to obtain statements of net foods consumed for egg production. The theoretical food requirement per lb. increase in liveweight of poultry is in the region of 4 lbs., but under general farm conditions it is more likely to be 4½ lbs. In the absence of any accurate statements the weight of poultry produced for slaughter must be estimated from the recorded sales of table poultry, old hens, and culls.

The theoretical annual food consumption per laying bird will be in the region of 90-95 lbs., but it will be seen that only 23 flocks consumed less than 100 lbs. and in 16 cases the food consumption exceeded 120 lbs. per bird. These estimates of food consumption by laying flocks include foods consumed in the production of pullets necessary for the maintenance of the laying flocks. The

TABLE II.

Estimated Net Food Consumption by Laying Flocks.

Per Bird		*Per Dozen Eggs*	
Range in lbs.	*No. of Cases*	*Range in lbs.*	*No. of Cases*
140 and over	9	14 and over	4
130 and under 140	3	12 and under 14	6
120 ,, ,, 130	4	10 ,, ,, 12	14
110 ,, ,, 120	10	8 ,, ,, 10	14
100 ,, ,, 110	7	6 ,, ,, 8	11
90 ,, ,, 100	7	Under 6	7
Under 90	16		
	56		56

economy of food consumption, however, is not measured by the relative quantities consumed per bird for account must be taken of egg production. In general, the high yielding birds consumed most food and the estimated food consumption for 12 flocks giving yields in excess of 160 eggs amounted to about 127 lbs. It is probable that a considerable part of this extra food would be due to the annual production of larger proportions of pullets to replace older hens in the flocks. A further group of 14 flocks with a mean yield of 149 eggs had an estimated food consumption of 105 lbs. and a group of 11 flocks with a mean yield of 129 eggs consumed about 103 lbs. of food per bird.

TABLE III.

Egg Yield and Net Food Consumption.

Mean Results.

Number of flocks	*Yield per bird*	*Food per bird*	*Food per doz. eggs*	*Mash % of all Foods*
	No.	*lbs.*	*lbs.*	%
12	177	127	8.6	61
19	149	105	8.5	47
11	129	103	9.6	44
14	99	92	11.2	28
Total 56	139	106	9.4	45

Flocks giving yields of less than 120 eggs consumed about 92 lbs. of food, but the results indicate that these flocks tended to be the least efficient converters of grain and meal into eggs. Only three of the fourteen flocks giving low yields consumed less than 8 lbs. of feed for every dozen eggs produced and ten of them had a feed consumption of more than 10 lbs. per dozen eggs. It seems probable that there were only small differences as regards efficiencies of flocks giving high and medium yields. But it is almost certain that flocks giving the higher yields and consuming a ration containing a larger proportion of mash and meals gave better winter production.

In periods of shortage of concentrated foods there seems to be some possibility that large specialist poultry enterprises will be discouraged while every effort is made to encourage the development of small back yard flocks. There can be very little criticism to offer against very small flocks which can be utilised to consume household waste, but if such flocks are allowed to exceed 12 to 15 birds then there will be a real danger of wastage of grain products. The justification for the existence of back-yard flocks lies in the contention that they will not be serious competitors with other livestock for grain feed and their size must quite definitely be limited. Flocks which require large quantities of purchased foods will make the best contribution to the supply of human food requirements when under the control of a skilled and experienced manager.

The collected records do not indicate any marked differences in the efficiencies of laying flocks of different sizes. Owners of large specialist flocks quite definitely get better production from their birds. To obtain these better yields they are forced to feed larger quantities of a high protein ration to the birds.

TABLE IV.

Size of Laying Flocks and Net Food Consumption.

Mean Results.

Number of flocks	*Size*	*Yield per bird*	*Food per bird*	*Food per dozen Eggs*	*Mash % of all Foods*
		No.	*lbs.*	*lbs.*	%
8	750	170	131	9.4	60
15	347	133	98	9.1	44
18	154	133	103	9.7	46
15	67	135	104	9.3	39
Total 56	267	139	106	9.4	45

Not one of the large flocks gave yields of less than 140 eggs per bird and in five cases the yields exceeded 160 eggs. Flocks ranging between 200 and 500 laying birds gave yields of between 140 and 160 eggs, but nine gave yields of more than 160. Yields from flocks of less than 200 birds extended fairly evenly over a very wide range. The mean yields for the three size groups below 500 birds were approximately the same and the food consumption per bird is also about the same.

It will be seen that the mean food consumption per dozen eggs produced is about the same for all size groups and also that the nature of the ration used by owners of flocks of less than 500 birds is in general the same. There was no instance of a large flock having an estimated food consumption of less than 6 lbs. per dozen eggs, and in four it exceeded 10 lbs. One third of the flocks having between 200 and 500 birds consumed more than 10 lbs. per dozen eggs produced and about one-half of the flocks in each of the other two size groups consumed more than 10 lbs. per dozen eggs produced.

In formulating national food production policies under war-time conditions it is necessary to take account of the relative merits of converting grain feed into animal products or of making them directly available for human foodstuffs. Livestock such as cattle, horses and sheep are only partially competitive with humans for grain produce since a large part of their total food requirements can be obtained from grass and roughage. Under less intensive management their demand for cereals can be reduced without any reduction in numbers. With poultry and pigs, however, a high proportion of the total feed requirement consists of products which could, if necessary, be directly processed into human foodstuffs. An important part of the supplies of grain and grain products used by poultry and pigs are imported and under war conditions these supplies are delayed and in some cases definitely restricted. It is for these reasons that poultrymen felt the effects of a shortage of supplies of poultry foods during the winter of 1939-40.

Some of the factors to be taken into consideration in determining the supplies of foods for poultry are :—

(1) the nature of existing and future supplies of animal products for human consumption,
(2) the nature of existing and future supplies of grain products which can be processed into human foodstuffs,
(3) the nature of existing and future supplies of cereals and cereal by-products available for animal feeding,
(4) the nature of existing and future supplies of grass and roughage available for animal feeding,
(5) the need to strike some balance between cows, cattle and sheep for purposes of consuming roughage and maintaining proper grazing of the pastures,
(6) the existing and future demand for horses for farm and other work,
(7) the relative merits of pigs and poultry as converters of cereal products and household waste into human foodstuffs.

In addition to these general considerations there are others which will ultimately decide the particular type of poultry business that is to be encouraged. Under any circumstances small back-yard flocks and relatively small flocks on general farms would be encouraged. In the one case the birds would use up household waste and in the second case they would consume household waste and in addition obtain a further part of their food requirements about the farmstead. In both cases the demand for purchased foods would be relatively small.

There is, however, a very definite limit (a) to the possibility of such flocks supplying any appreciable part of the existing home supplies of table poultry and eggs, and (b) to the maintenance of such flocks on the minimum of purchased foods. With an increase in the acreage sown to cereals the possibility of general farm flocks finding a larger part of their own food requirements will increase, but in almost every case except the very small back-yard flock an important part of the total laying birds will be dependent upon either home grown or imported grain and grain products. In all cases where flocks are mainly dependent upon purchased poultry foods, it is important to consider whether any particular type of enterprise both as regards size and intensity of production has any special advantage from the national standpoint. The records when grouped according to size of laying flocks showed no particular advantage as regards the efficiency of food consumption per dozen eggs produced. The larger flocks however produce a larger quantity of eggs per bird though the feeds used necessarily contain a higher proportion of relatively high protein foods.

Although yields from the larger flocks tend to reach the higher levels very good production is shown for some of the smaller flocks. If the estimated annual production of hen eggs for 1937-38 had been obtained from flocks giving yields of more than 140 eggs per bird, the total food consumed would probably have been 260,000 tons less than that which would have been required had this number of eggs been produced by flocks giving less than 120 eggs per bird. Not only will there be some considerable saving in poultry food, but the labour and capital requirements per dozen eggs will be lowest for the flocks giving high yields. If the necessary protein feeds can be obtained then high yields will be preferable to medium yields.

The chief point for consideration, however, is the relative merits of the specialist and the ordinary general farm flock. There has been a considerable improvement in most flocks on general farms, but in many instances they are very inefficient converters of poultry foods into eggs. It is not sufficient to say that such flocks consume, to a considerable extent, only home grown foods for in such cases it would still be preferable to give such foods to cows and possibly to pigs. It would almost certainly be preferable for a large number of farmers to sell their cereals to specialist poultrymen rather than feed them to their own flocks. There seems to be no sound reason for any direct limitation of the activities of the efficient specialist poultryman while the inefficiently managed flocks on general farms are allowed to consume cereals, whether purchased or home grown. Selection of birds and internal care and management of the flock are far more important than any external circumstances, such as size or environment, in determining the quantity of food required per unit of eggs produced.

CHANGES IN PRODUCTION OF MILK AND IN CERTAIN ITEMS OF PRODUCTION COSTS ON NINETEEN FARMS IN WALES FOR OCTOBER—MARCH, 1938-9 AND 1939-40.

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A comparative study is made for the same 19 herds for the winter periods (October-March) 1938-39 and 1939-40 regarding changes in herd transactions, milk output, food and labour costs.

For these 19 farms the proportion of cows in milk, suckling and dry remain practically the same in both periods, but the number of cows kept decreased by 2.5 per cent in October-March, 1939-40. (See Table I).

Herd transactions are fully set out in Table II, which shows very little of changes in value from one winter to the next, except in the cases of outgoing cows, and of calves where values were appreciably higher. These values of incoming cows in the past winter do not wholly represent general changes in prices of cows, but they show the actual conditions on these farms.

TABLE I.

Monthly Index Number and changes in Number of Cows for period October—March, 1938-39, and 1939-40.

	Number of Cows in Herd	*Number of Cows in Milk*
	(Index No.)	*(Index No.)*
October, 1939 (October, 1938 = 100)	97.8	96.5
November, 1939 (November, 1938 = 100)	97.1	95.5
December, 1939 (December, 1938 = 100)	96.5	98.2
January, 1940 (January, 1939 = 100)	97.4	101.2
February, 1940 (February, 1939 = 100)	98.8	99.3
March, 1940 (March, 1939 = 100) ..	98.9	98.2
October-March, 1939-40 (October-March, 1938-39 = 100) ..	97.7	97.8

	October-March, 1938-39	*% to Total*	*October-March,* 1939-40	*% to Total*
Number of Cows in Milk	312	71.6	304	71.4
Number of Cows Suckling	9	2.0	10	2.3
Number of Cows Dry	115	26.4	112	26.3
Total Number of Cows	436	100.0	426	100.0

TABLE II.

Herd Transactions on 19 Farms for October-March, 1938-39 and 1939-40.

	October-March, 1938-39		*October-March,* 1939-40	
	No.	*Average Price*	*No.*	*Average Price*
		£ s. d.		£ s. d.
Purchases of Dairy Stock :				
Cows and Heifers in Milk	8	25 15 0	10	24 16 6
In-Calf Cows	1	19 10 0	3	22 0 0
In-Calf Heifers	1	12 10 0	1	24 0 0
Total Purchases	10	23 16 0	14	24 3 2
Transfers in of Dairy Stock :				
Home-bred Heifers	38	20 9 6	31	19 13 10
Other Heifers Bulled	6	16 8 4	1	25 0 0
Total Transfers in	44	19 18 5	32	19 17 2
Total Incoming Cows	54	20 12 9	46	21 3 4
Sales of Dairy Cows :				
Prime Cows	34	22 9 6	40	24 6 6
Other Cows (Fat, Barreners, etc.)	33	11 0 10	21	10 11 3
Carcases	6	0 2 7	4	—
Total Sales	73	15 9 5	65	18 7 8
Transfers out of Herds	4	5 0 0	2	5 12 6
Total Outgoing Cows	77	14 18 6	67	18 0 0
Calves born alive	216	2 1 5	207	2 4 8
Calves sold	123	1 19 3	114	2 1 8
Calves retained	93	2 3 9	93	2 5 7

Milk Production

In spite of the fact that there were fewer cows in the herd the total output of milk was higher in October and November, 1939, than for the corresponding months in 1938. For the remaining months the total output was lower than for the corresponding months in 1938-39. The higher milk yields per cow in the herd and per cow in milk in October and November, 1939, as compared with the same months in 1938, undoubtedly reflects the superiority of the grazing for these months in the former. The difference between the two years is less marked in December when the grass as such is not so important a factor in feed supply. The milk yield per cow in herd and in milk was lower in January and February, 1940, than for the corresponding months in 1939. This may be the result not only of scarcity of concentrated feedingstuffs, but also some lack of other suitable foods for dairy cows and to the severe weather conditions experienced during these months. In March (1940) while the yield is lower per cow in herd, the yield per cow in milk for that month is the same in both years. (See Table III).

TABLE III.

Milk Production on 19 Farms for October-March, 1938-39 and 1939-40.

			Yield per Cow			
Month	*Total Yield*		*In Herd*		*In Milk*	
	1938-39	1939-40	1938-39	1939-40	1938-39	1939-40
	Gallons	*Gallons*	*Gallons*	*Gallons*	*Gallons*	*Gallons*
October	19,050	19,544	43	45	52	55
November	16,322	16,784	37	39	46	50
December	18,330	17,932	41	42	59	57
January	15,146	13,938	35	33	53	48
February	16,296	14,711	38	35	58	52
March	22,078	20,881	52	50	71	71
Whole Period	107,222	103,790	41	40	56	55

It might have been expected that the milk output would have dropped considerably during the winter period (1939-40), but in comparison with the same period in 1938-39 the results as given in Table III show that the drop in the yield per cow in herd and in milk was very small.

Purchased Foods.

The classification of the purchased foods fed together with the total quantities used and the average price per cwt. for the periods October-March, 1938-39 and 1939-40 are given in Table IV. Of oil cakes and meals, which account for slightly over 89 per cent of the total purchased foods in each period, the total quantity fed was 10.4 per cent less in October-March, 1939-40, than for the same period in 1938-39. Of this class of concentrates, balanced rations formed the major part and represented nearly 78 per cent of total oil cakes and meals fed in October-March, 1938-39, and nearly 94 per cent in October-March, 1939-40. The quantity fed of ' balanced ration ' rose by nearly 6 per cent and the price by 12.4 per cent in October, 1939-40. Only a small quantity of grain were fed in both periods, but quantity used and price rose

TABLE IV.

Quantities and Costs of Purchased Foods on 19 Farms for October-March, 1938-39 and 1939-40.

	October-March, 1938-39		*October-March, 1939-40*		*Quantity Index No.*	*Price Index No.*
	cwts.	*Price per cwt.*	*cwts.*	*Price per cwt.*	*1938-39 = 100*	1938-39 = *100*
(1) *Oils and Meals*:		s. d.		s. d.		
Balanced Ration	3,236¼	8 9	3,457½	9 10	106.8	112.4
Ground Nut Cake ..	234½	8 6	40¾	9 7	17.4	112.7
Dec. Cotton Cake	64¾	8 2	19½	9 4	30.1	113.1
Palm Kernel ..	84½	7 11	48¾	8 4	57.7	104.2
Uveco ..	240¾	7 10	34¼	9 3	14.2	118.1
Indian Meal ..	197½	7 4	69	8 2	34.9	111.4
Molasine ..	53	8 0	10	9 2	18.9	114.6
Linseed Cake ..	—	—	2	9 4	—	—
Total ..	4,111¼	—	3,681¾	—	89.6	—
(2) *Grains*:						
Oats	43½	8 2	91¾	9 11	210.9	120.2
Wheat	36	6 10	4	14 6	11.1	212.2
Barley	—	—	3	9 2	—	—
Total ..	79½	—	98¾	—	124.2	—
(3) *Milling Offals*:						
Bran	303	7 7	126¾	7 7	41.8	100.0
Weatings ..	36	7 5	45	7 9	125.0	104.5
Total ..	339	—	171¾	—	50.7	—
(4) *Miscellaneous*:						
Hay	70	6 10	145	7 6	85.3	109.7
Beet Pulp ..	—	—	2	9 6	—	—
Brewers' Grain	—	—	23	9 0	—	—
Total ..	70	—	170	—	242.9	—
Total (All Foods)	4,599¾	8 5	4,122¼	9 7	89.6	113.8

in October-March, 1939-40. Milling offals (bran and weatings) amounted to 7.4 per cent of purchased foods in October-March, 1938-39, and 4.2 per cent in 1939-40. The reduction in quantity of bran fed in October-March, 1939-40, was slightly over 58 per cent, but the price remained unchanged. More weatings were used in October-March, 1939-40, and the price increased by 4.5 per cent. Of miscellaneous foods, small quantities of hay were bought in both periods, but purchases of beet-pulp and brewers' grains were only made in the period October-March, 1939-40. For all classes of purchased foods there was a reduction of 10.4 per cent in the quantity bought and a rise of 13.8 per cent in the price over the period October-March, 1938-39.

Home-Grown Foods

A classification of home-grown foods together with their value is set out in Table V. These values are based on the average market prices of a representative group of foodstuffs commonly used in making up rations, so values of home-grown foods are fixed according to their starch and protein content and the comparative cost of these contents as they might be purchased in the form of the representative group of feeds. The figures used for home-grown foods therefore do not necessarily represent either cost or market price.

As will be seen from Table V. there was a marked reduction in home-grown bulk foods and home-grown concentrates fed in October-March, 1939-40. The reduction in bulk foods being 15.4 per cent and in concentrates 35.6 per cent. Of bulk foods, the quantity of hay fed was reduced by 20.5 per cent, straw by 2.9 per cent and green crop by 62.1 per cent. Off-setting this reduction was an increase of 23.1 per cent in the quantity of silage fed and 27.4 in the quantity of roots fed.

TABLE V.

Quantities and Costs of Home Grown Foods on 19 Farms for October-March, 1938-39 and 1939-40.

	October-March, 1938-39		*October-March,* *1939-40*		*Quantity Index No.*	*Price Index No.*
	Cwts.	*Price per cwt.*	*Cwts.*	*Price per cwt.*	*1938-39 = 100*	*1939- 40 = 100*
(1) *Bulk Foods*:		s. d.		s. d.		
Hay	6,505	3 7	5,168¾	3 8	79.5	102.3
Silage ..	1,415	1 3	1,742	1 3	123.1	100.0
Straw ..	777	1 10	754½	1 11	97.1	104.5
Roots ..	1,151½	0 8	1.467	0 8	127.4	100.0
Green Crop	1,742	0 11	661	0 11	37.9	100.0
Total ..	11,590½	—	9,793¼	—	84.6	—
(2) *Concentrates*:						
Oats ..	297¾	5 8	157¾	5 11	53.0	104.4
Barley ..	—	—	21½	6 10	—	—
Mixed Corn ..	204	6 3	144	6 4	70.6	101.3
Total ..	501¾	—	323¾	—	64.4	—
Total ..	12,092½	2 7	10,116½	2 7	83.6	100.0

Foods fed per cow and per gallon.

Reference has already been made to the fact that fewer cows were kept in these herds during the period October-March, 1939-40, than for the corresponding period in 1938-39. This

TABLE VI.

Quantities of Bulk and Concentrated Foods fed per Cow (lb.).

	October.		*November*		*December*		*January*		*February*		*March*		*October-March*	*October-March*
	1938	*1939*	*1938*	*1939*	*1938*	*1939*	*1939*	*1940*	*1939*	*1940*	*1939*	*1940*	*1938-39*	*1939-40*
	lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs,*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Hay	10	—	112	53	393	288	345	317	372	347	474	403	1,689	1,397
Silage	5	—	34	25	77	78	74	103	74	110	102	145	364	458
Straw	—	—	11	10	37	38	43	41	50	34	61	76	199	198
Roots	—	—	—	5	24	63	46	89	95	141	137	91	296	386
Green Crops	44	—	104	68	141	87	99	19	53	—	—	—	447	174
Total Bulk Foods ..	59	—	261	161	672	554	607	569	644	632	774	715	2,995	2,613
Home Grown Corn ..	5	1	15	6	29	22	25	24	26	16	29	17	129	85
Purchased Cakes and Meals	133	147	154	172	215	207	193	154	205	156	268	210	1,164	1,046
Total Concentrates ..	138	148	169	178	244	229	218	178	231	172	297	227	1,293	1,131

factor in itself would be responsible for some reduction in feed requirements for these herds. A better indication of quantities fed would therefore be obtained by expressing the results in terms of foods fed per cow in herd and per gallon of milk produced. This is shown in Tables VI and VII. In October, 1939, there were no bulk foods fed and in November and December, 1939, there was a marked reduction as compared with the corresponding months in 1938 not only in the total quantity of bulk foods used, but practically in all classes of bulk foods fed. It is also noticeable that smaller quantities of total bulk food were used per cow in January, February and March, 1940, as compared with the corresponding months in 1939. For each of the six months less hay was used in 1939-40, than in 1938-39, but against this reduction there were larger quantities of silage fed in January, February and March, 1940. On a per cow basis the hay fed for the period October-March, 1939-40, was reduced by about 16 per cent and the silage fed increased by 26 per cent, but bulk of hay was 3 to 5 times that of silage. Less concentrates were fed per cow in all months (except October and February) in the period October-March, 1939-40, than in the corresponding months in 1938-39. Quantities of bulk foods and concentrates fed per cow and per gallon of milk produced for the period October-March, 1938-39 and 1939-40, is as herewith stated :—

	Per Cow.		*Per Gallom.*	
	October-March, 1938-39	*October-March, 1939-40*	*October-March, 1938-39*	*October-March, 1939-40*
	lb.	*lb.*	*lb.*	*lb.*
All Bulk Foods ..	2,995	2,613	12.18	10.72
All Concentrates	1,295	1,131	5.25	4.64

In spite of the smaller quantities fed, yields as already stated have been fairly well maintained (see Table III) and the feedingstuffs position appears to have been somewhat easier on these 19 farms during the period October-March, 1939-40, than in 1938-39. There is no doubt that the plentiful supply of grass during the autumn of 1939 helped the dairy farmer to conserve his stocks of home-grown fodder and the open weather assisted him to take full advantage of the satisfactory state of the pastures. It is also possible that the advent of war and apprehension about the supply of feedingstuffs resulted in more economy in the use of both purchased and home-grown foods. It might have been expected that the increase in the price of purchased foods would have been higher than reflected in the returns for these 19 farms, but a possible explanation of this is that in anticipation of war, forward supplies were bought when prices were fairly normal.

TABLE VII.

Quantities of Bulk and Concentrates fed per gallon (lb.).

	October.		*November*		*December*		*January*		*February*		*March*		*October-March*	*October-March*
	1938	*1939*	*1938*	*1939*	*1938*	*1939*	*1939*	*1940*	*1939*	*1940*	*1939*	*1940*	*1938-39*	*1939-40*
	lbs.	*lbs.*	*lbs.*	*lbs*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Hay	0.22	—	3.04	1.37	9.49	6.87	9.95	9.69	9.73	9.93	9.03	8.03	6.87	5.73
Silage	0.12	—	0.94	0.65	1.86	1.86	2.13	3.16	1.92	3.15	1.95	2.90	1.48	1.88
Straw	—	—	0.29	0.27	0.89	0.91	1.24	1.26	1.31	0.98	1.17	1.52	0.81	0.82
Roots	—	—	—	0.12	0.59	1.50	1.33	2.72	2.47	4.04	2.60	1.82	1.20	1.58
Green Crops	1.05	—	2.83	1.74	3.42	2.07	2.88	0.56	1.41	—	—	—	1.82	0.71
Total Bulk Foods ..	1.39	—	7.10	4.15	16.25	13.21	17.53	17.39	16.84	18.10	14.75	14.27	12.18	10.72
Home Grown Corn ..	0.12	0.02	0.42	0.14	0.69	0.52	0.72	0.72	0.69	0.46	0.55	0.34	0.52	0.35
Purchased Cakes and Meals	3.10	3.28	4.19	4.43	5.19	4.93	5.58	4.70	5.36	4.46	5.11	4.19	4.73	4.29
Total Concentrates ..	3.22	3.30	4.61	4.57	5.88	5.45	6.30	5.42	6.05	4.92	5.66	4.53	5.25	4.64

This reduction in the quantity of foods used, together with the fact that yields have been fairly well maintained, has resulted in a slight reduction in costs per gallon of food (other than grass) over the six months October-March, 1939-40, as compared with 1938-39. The exact position for each month and the average for the six months in each period is as shown in Table VIII.

The results indicate a rise of 0.25d. per gallon in the cost of purchased foods, a fall of 0.55d. per gallon in the cost of home-grown foods and a decrease of 0.3d in total cost of foods per gallon in the period October-March, 1939-40, as compared with that in 1938-39.

TABLE VIII.

Food Cost per Gallon.

Month	*Purchased*		*Home-Grown*		*Total Food*	
	1938-39	*1939-40*	*1938-39*	*1939-40*	*1938-39*	*1939-40*
	d.	*d.*	*d.*	*d.*	*d.*	*d.*
October ..	2.87	2.98	0.27	0.02	3.14	3.00
November ..	3.88	4.27	1.92	0.92	5.80	5.19
December ..	4.43	5.64	4.97	3.68	9.40	8.72
January ..	5.12	5.19	4.93	5.09	10.05	10.28
February ..	4.88	5.26	5.11	5.00	9.99	10.26
March ..	4.95	5.09	4.34	4.11	9.29	9.20
Average ..	4.34	4.59	3.56	3.01	7.90	7.60

Manual Labour hours and costs.

In Table IX is given the labour per cow and per 100 gallons of milk produced. The figures show a reduction in the hours worked of 6.3 per cent per cow and 8.1 per cent per 100 gallons over the period October-March, 1940. A reduction in the hours worked is also noticeable for each month as compared with the corresponding months in the preceding period, except in January and February, 1940, when a small rise occurred in the manual labour hours per 100 gallons.

As a result of the reduction in number of hours worked the total labour costs showed a slight fall over the period October-March, 1940, but the cost per hour was slightly increased because of the higher rate of wages paid. The average rates for unpaid and hired labour on these 19 farms appear in Table X.

TABLE IX.

Manual Labour (Hours).

	October.		*November*		*December.*		*January.*		*February.*		*March.*		*October-March 1938-39*	*October-March 1939-40*
	1938	*1939*	*1938*	*1939*	*1938*	*1939*	*1939*	*1940*	*1939*	*1940*	*1939*	*1940*		
	Per Cow.													
Family	8.74	7.86	8.98	8.44	11.46	10.77	8.80	8.70	9.22	8.94	11.27	11.20	58.44	55.87
Hired	5.00	4.19	4.99	4.50	6.30	6.25	5.43	4.99	5.70	5.12	7.39	6.49	34.74	31.50
Total Labour	13.74	12.05	13.97	12.94	17.76	17.02	14.23	13.69	14.92	14.06	18.66	17.69	93.18	87.37
	Per 100 *Gallons.*													
Family	20.41	17.51	24.43	21.68	27.70	25.67	25.41	26.60	24.10	25.58	21.50	22.34	23.76	22.93
Hired	11.69	9.35	13.56	11.56	15.23	14.90	15.69	15.24	14.91	14.65	14.08	12.94	14.13	12.93
Total Labour	32.10	26.86	37.99	33.24	42.93	40.57	41.10	41.84	39.01	40.23	35.58	35.28	37.89	35.86

TABLE X.

Labour Cost per Hour.

Month	*Family Labour*		*Hired Labour*		*Total Labour*	
	1938-39	*1939-40*	*1938-39*	*1939-40*	*1938-39*	*1939-40*
	d.	*d.*	*d.*	*d.*	*d.*	*d.*
October ..	6.92	7.25	5.93	6.24	6.56	6.90
November ..	6.90	7.27	6.00	6.44	6.58	6.99
December ..	7.02	7.35	6.16	6.37	6.72	6.99
January ..	7.11	7.44	6.15	6.37	6.75	7.05
February ..	7.10	7.40	6.14	6.32	6.73	7.01
March ..	7.02	7.36	6.11	6.37	6.66	7.00
Average	7.01	7.35	6.09	6.43	6.67	6.99

The labour cost per gallon is given in Table XI.

Compared with October-March, 1938-39, the change in labour costs per gallon were small. Cost of family labour rose by 0.02d. per gallon, cost of hired labour fell by 0.04d. per gallon and cost of total labour decreased by 0.02d. per gallon.

TABLE XI.

Labour Cost per Gallon.

Month	*Family Labour*		*Hired Labour*		*Total Labour*	
	1938-39	*1939-40*	*1938-39*	*1939-40*	*1938-39*	*1939-40*
	d.	*d.*	*d.*	*d.*	*d.*	*d.*
October ..	1.41	1.27	0.69	0.58	2.10	1.85
November ..	1.69	1.58	0.81	0.74	2.50	2.32
December ..	1.94	1.89	0.94	0.95	2.88	2.84
January ..	1.81	1.98	0.96	0.97	2.77	2.95
February ..	1.71	1.89	0.92	0.92	2.63	2.81
March ..	1.51	1.64	0.86	0.82	2.37	2.46
Average ..	1.67	1.69	0.86	0.82	2.53	2.51

Summary

While the records for these 19 herds indicate a reduction of 2.5 per cent in number of dairy cows for the period October-March, 1939-40, the total milk output has only declined by 1.2

per cent. Yields have therefore been fairly well maintained and averaged 244 gallons per cow in herd and 341 gallons per cow in milk for the six months October-March, 1939-40, as compared with 246 gallons per cow in herd and 344 gallons per cow in milk for the corresponding period in 1938-39. Dairy stock bought averaged £24 3s. 2d. per head in October-March, 1939-40, and £23 16s. 0d. each in October-March, 1938-39. Dairy stock sold realised £18 7s. 8d. per head in October-March, 1939-40, and £15 9s. 5d. in October-March, 1938-39. Calves sold averaged £2 6s. 8d. per head in October-March, 1939-40, and £1 19s. 3d. in October-March, 1938-39. Over all prices of purchased foods rose by nearly 14 per cent, but as a result of lower quantities fed the increase in cost for the period October-March, 1939-40, only amounted to 0.25d. per gallon. Quantities of home-grown foods fed were also reduced and costs fell by 0.55d. per gallon. For all foods there was a reduction in costs of 0.30d. per gallon in October-March, 1939-40. Costs per hour of manual labour rose, but as a result of a decrease in the number of hours worked the cost of labour fell by 0.02d. per gallon in October-March, 1939-40.

FINANCIAL RESULTS ON SIXTY-THREE FARMS IN WALES (1937-8 AND 1938-9).

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Accounts for two consecutive years are available for the same 63 farms and from the accounting data it is possible to show the financial results of four farming types which could be found in any area covering the lowland or valleys, hills and higher uplands in Wales. The classification of the type-groups is done on the basis of the knowledge of the farms, together with an examination of the sources of receipts. The chief sales of all these type-groups are of livestock and livestock products, but the proportion of sales of sheep, cattle, dairy produce, milk, etc., vary in the different type-groups.

Type I: Cattle and Sheep (Poor Land).

About 74 per cent of the total area of these farms is rough grazing, about 22 per cent is pasture and hay and the remainder is arable. Practically all the crops are grown for the maintenance of livestock and direct sale of crops on these farms is almost negligible. Rentals are low and average about 3s. 11d. per acre with variations between 1s. 5d. and 8s. 9d. per acre. While the average size is about 317 acres the range is from 79 to 764 acres. Practically all receipts are obtained from the sale of livestock and livestock products. The percentage distribution being approximately as follows :—Cattle and dairy produce 59 per cent, sheep and wool 27 per cent, pigs, poultry and eggs and horses 11 per cent, and crops and sundries 3 per cent. Of expenses, rent, hired labour and family labour, livestock replacements and feedingstuffs are the main items. These constitute about 78 per cent of total expenditure. Employment of labour is low and does not average one person per 100 acres.

Type 2 : Sheep and Cattle (Better Land).

Nearly 91 per cent of the land is under grass. About 57 per cent is pasture and hay, 9 per cent is arable, and about 34 per cent is rough grazing. As in Type 1, the sale of crops is of very minor importance and the major part of the receipts are derived from the sale of cattle and dairy products and sheep and wool. The average size of holding is 210 acres with a variation of from 61 to 486 acres. The rents range from 8s. 2d. to 30s. 1d. per acre with an average rental of about 15s. 10d. per acre. Receipts are much higher than in Type I and the percentage distributions of cattle and dairy produce are about 48 per cent, sheep and wool 30 per cent, pigs 7 per cent, poultry and eggs 6 per cent, horses 4 per cent, while only about 3 per cent of receipts is derived from crops. Capitalisation is about three times as high as in Type 1 and total expenditure is considerably greater. Of expenses, rent and rates are about 19 per cent, hired and family labour 26 per cent, livestock replacements 27 per cent, feedingstuffs 15 per cent, and the remainder is for manures, seeds, implements and sundry items. The amount of labour used is less than two persons per 100 acres.

Type 3 (Mixed Farms).

More prominence is given to the cultivation of arable crops than on any of the other type-groups, but even on this type-group about 86 per cent of the land is under grass and of this the area of rough grazing is about 13 per cent. The farms range in size from 30 to 296 acres. Rentals vary from 13s. 9d. to 31s 1d. with an average rental of about 25s. per acre. Stocking is relatively heavy and is the equivalent of slightly over two acres to a cow. While the cattle enterprise is important, the output of pigs and poultry and eggs are higher than in the other type-groups. Receipts are over twice as much as in Type 2 and mainly derived from the livestock enterprises. The approximate percentage distribution is: cattle and dairy produce 47 per cent, sheep and wool 11 per cent, pigs 26 per cent, poultry and eggs 7 per cent, horses 3 per cent, and crops about 4 per cent. The main items of expenditure are rent and rates about 15 per cent, family and hired labour 18 per cent, feedingstuffs 33 per cent, livestock replacements 24 per cent. The amount expended on manures and seeds is small. Nearly three persons are fully engaged per 100 acres.

Type 4 (Dairy Farms).

About 90 per cent of the land is under grass of which hay represents approximately 28 per cent, pasture 60 per cent, and rough grazing about two per cent. More stock is carried than in Type 3 and reaches the equivalent of one cow to two acres. Capitalisation is higher than in any of the other three type-groups and is about £14 per acre. The farms average in size 77 acres and range from 18 to 184 acres. Rents average about 30s. per acre with variations from 13s. 0d. to 60s. 0d. per acre. Receipts are higher than those in Type 3 and approximately 95 per cent of the receipts are obtained from livestock and livestock products. The percentage distribution is as follows:—cattle and dairy produce about 76 per cent, sheep and wool 7 per cent, pigs 6 per cent, poultry and eggs 5 per cent, and horses and crops slightly over 1 per cent each. Expenses are also higher than in Type 3. The main items being—rent and rates 14 per cent, wages 19 per cent, feedingstuffs 34 per cent, and livestock replacements 15 per cent. The remainder being made up of expenditure on seeds, manures, implements and sundry items. These together represent about 18 per cent of total expenses—of which manures and seeds amount to less than 3 per cent. The amount of labour employed is the highest of all types, being over three persons fully engaged per 100 acres.

The total area covered by these type-groups for each period together with the average rent per farm and per acre is stated in Table I. Apart from some slight increases in acreage and rentals in the Cattle and Sheep (Better Land) and Mixed Farms groups there is no change as between the two periods. (Table I.)

Changes in Land Utilisation.

The average size of these 63 farms increased slightly, but the area under arable crops declined by 5 per cent (Table II). While the acreage under wheat remained the same in both years there was a reduction in the area under oats and mixed corn in 1938-9, with some increase in the area under barley. Acreages under other

TABLE I.

Total Acres, Average Size of Farms and Rentals.

Type Group	*Cattle and Sheep (Poor Land)*		*Cattle and Sheep (Better Land)*		*Mixed Farms*		*Dairy Farms*		*All Farms*	
	1937-8	*1938-9*	*1937-8*	*1938-9*	*1937-8*	*1938-9*	*1937-8*	*1938-9*	*1937-8*	*1938-9*
No. of Farms	16	16	15	15	10	10	22	22	63	63
Total Acres	5,072	5,072	3,170	3,160	1,141	1,186	1,695	1,695	11,078	11,113
Average Size of Farms (acres)	317	317	211	210	114	119	77	77	176	176
Rent per Farm	£ 62.6	£ 62.5	£ 166.2	£ 167.5	£ 138.5	£ 152.8	£ 114.7	£ 116.8	£ 117.5	£ 120.8
Rent per acre	s. d. 3 11	s. d. 3 11	s. d. 15 9	s. d. 15 11	s. d. 24 3	s. d. 25 9	s. d. 29 9	s. d. 30 3	s. d. 13 4	s. d. 13 8

TABLE II.

Arable Land, Hay, Pasture and Rough Grazing per 100 acres.

Type Group	*Cattle and Sheep (Poor Land)*		*Cattle and Sheep (Better Land)*		*Mixed Farms*		*Dairy Farms*		*All Farms*	
	1937-8	*1938-9*	*1937-8*	*1938-9*	*1937-8*	*1938-9*	*1937-8*	*1938-9*	*1937-8*	*1938-9*
Corn	3.0	2.9	7.8	7.2	11.1	10.5	7.0	6.7	5.9	5.5
Other Crops	0.7	0.5	2.0	1.9	2.8	3.1	2.9	2.7	1.6	1.5
Total Arable ..	3.7	3.4	9.8	9.1	13.9	13.6	9.9	9.4	7.5	7.0
Hay	8.5	8.4	15.8	15.5	25.5	25.8	27.9	28.9	15.3	15.4
Pasture	13.6	14.0	40.6	41.8	47.2	47.6	60.8	60.3	32.0	32.6
Rough Grazing	74.2	74.2	33.8	33.6	13.4	13.0	1.4	1.4	45.2	45.0
Total Pasture ..	96.3	96.6	90.2	90.9	86.1	86.4	90.1	90.6	92.5	93.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

crops were lower than in 1937-8, except in the case of potatoes and miscellaneous crops, which showed increases of 8 per cent and 30 per cent respectively.

Changes in Number of Livestock Carried.

The different kinds of livestock carried and the variation in their use and management are reflections of the type of farming in each group. On the basis of livestock carried per 100 acres, the type-groups other than the Cattle and Sheep (Poor and Better Land) carry a large head of cattle, pigs, and poultry and there is not so much prominence given to the breeding of sheep. On the same comparative basis the Dairy Farms carry a larger head of dairy cows than the Mixed Farms while the pig population is considerably higher on the Mixed Farms than in any of the other type-groups. Prominence is given to poultry only on the Dairy and Mixed Farms. A comparison of the records for the two years reveals a few interesting though small changes. Over all farms dairy cows and ' other ' cattle have increased by 4 per cent each, breeding ewes by 2 per cent but ' other ' sheep have remained at about the same level in both years. There has been some slight increase in the number of breeding sows in 1938-9, but ' other ' pigs declined by 7 per cent. The number of poultry fell by 7 per cent in 1938-9 and this decline was heaviest in number of laying birds. (Table III).

Financial Results

The farmers' profit (Farm Income) as set out in Table IV represents the balance between receipts and expenses after allowing for valuation differences during the financial year. Expenditure on labour includes an allowance at current rates for unpaid family labour other than that for the occupier and his wife. The value of the farm produce consumed in the house and the rent of the farmhouse at rateable value is included in receipts. The farm income can therefore be taken as the amount available to remunerate the occupier (the farmer and his wife) for work and management and for capital.

Reference to Table IV will show that the 'cash balance' for these farms has risen by £8 per farm in 1938-9 but owing to a decline in valuation the farm income has fallen by £46.4 per farm. All type-groups show an improvement in 'cash balance' except the Cattle and Sheep (Better Land) where the decline has been very severe and this is the only group which has failed to show a farm income. This is due chiefly to lower prices for sheep and to a reduced output of cattle. Farm incomes have also fallen for all type-groups—the only group that has maintained about the same

TABLE III.

No. of Livestock carried per 100 Acres.

Type Group.	Cattle and Sheep (Poor Land)		Cattle and Sheep (Better Land)		Mixed Farms		Dairy Farms		All Farms	
	1937–8	1938–9	1937–8	1938–9	1937–8	1938–9	1937–8	1938–9	1937–8	1938–9
Average Size of Farm (acres)	317	317	211	210	114	119	77	77	176	176
Work Horses	0.5	0.5	1.6	1.6	3.0	2.8	3.2	3.2	1.5	1.5
Other Horses	0.1	0.2	1.8	1.9	0.9	1.3	1.6	1.9	0.9	1.0
Total Horses ..	0.6	0.7	3.4	3.5	3.9	4.1	4.8	5.1	2.4	2.5
Dairy Cows	2.2	2.3	4.7	5.0	14.3	14.0	22.9	24.0	7.3	7.6
Other Cattle	6.3	6.5	15.2	15.6	21.6	21.1	20.6	22.4	12.6	13.1
Total Cattle	8.5	8.8	19.9	20.6	35.9	35.1	43.5	46.4	19.9	20.7
Breeding Ewes	51.1	50.6	65.9	68.1	48.6	49.7	36.1	40.3	52.8	53.9
Other Sheep	30.8	30.9	52.5	50.5	39.8	37.9	20.3	24.7	36.3	36.3
Total Sheep	81.9	81.5	118.4	118.6	88.4	87.6	56.4	65.0	89.1	90.2
Breeding Sows	0.1	0.1	0.7	0.8	2.0	2.3	2.3	2.0	0.8	0.8
Other Pigs	0.4	0.5	3.3	2.8	25.0	22.8	9.9	9.0	5.3	4.9
Total Pigs	0.5	0.6	4.0	3.6	27.0	25.1	12.2	11.0	6.1	5.7
Laying Flock	10.1	10.3	39.9	37.8	111.9	106.4	105.3	84.6	43.7	39.7
Other Poultry	6.7	6.2	31.2	23.3	75.1	94.9	86.4	75.6	33.0	31.1
Total Poultry ..	16.8	16.5	71.1	61.1	187.0	201.3	191.7	160.2	76.7	70.8
Animal Units (Cows) ..	16.0	16.3	29.8	30.2	45.3	44.1	48.4	50.5	27.9	28.4

TABLE IV.

Farm Income in £ per Farm.

Year	*No. of Farms*	*Receipts*	*Expenses*	*Cash Balance*	*Valuation Difference*	*Farm Income*
		£	£	£	£	£
		Cattle and Sheep (Poor Land).				
1937–8	16	427.4	352.4	75.0	+69.0	144.0
1938–9	16	472.9	369.6	103.3	—39.0	64.3
		Cattle and Sheep (Better Land).				
1937–8	15	1,087.8	996.4	91.4	— 5.5	85.9
1938–9	15	918.1	907.6	10.5	—18.7	—8.2
		Mixed Farms.				
1937–8	10	1,231.7	1,129.3	102.4	+33.1	135.7
1938–9	10	1,230.0	1,088.0	142.0	—26.7	115.2
		Dairy Farms.				
1937–8	22	1,011.6	863.4	148.2	+67.1	215.3
1938–9	22	1,054.9	867.2	187.7	+26.3	214.1
		All Farms.				
1937–8	63	916.3	807.5	108.8	+45.0	153.8
1938–9	63	902.3	785.5	116.8	— 9.4	107.4

level in both years is the Dairy group. Valuation differences show depreciation of capital in 1938-9 for all type-groups except the Dairy Farms. This decline in valuation is mainly the result of the drop in prices of sheep and horses, together with a reduction in the number of poultry and closing stocks of hay. (Table V.)

TABLE V.

Capital per Farm.

Type-group.	*1937–8*		*1938–9*		*Average per acre*	
	Opening	*Closing*	*Opening*	*Closing*	*1937–8*	*1938–9*
	£	£	£	£	£	£
Cattle and Sheep (Poor Land) ..	813.5	882.5	882.5	843.5	2.67	2.72
Cattle and Sheep (Better Land) ..	1568.0	1562.5	1562.5	1543.8	7.40	7.37
Mixed ..	1394.6	1427.7	1427.7	1401.0	12.36	11.92
Dairying ..	1026.4	1093.0	1093.5	1119.8	13.75	14.38
All Farms ..	1159.7	1204.7	1204.7	1195.3	6.72	6.80

The number of profits and losses for each type-group is given in Table VI.

Over all farms there is an increase of losses in 1938-9 and while the position remains unchanged on the Mixed and Dairy Farm

TABLE VI.

Profit and Losses by Type-Group.

Year.		*Profit.*	*Loss.*	*Total.*
		Cattle and Sheep (Poor Land.		
1937–8	..	15	1	16
1938–9	..	14	2	16
		Cattle and Sheep (Better Land).		
1937–8	..	11	4	15
1938–9	..	7	8	15
		Mixed Farms.		
1937–8	..	8	2	10
1938–9	..	8	2	10
		Dairy Farms.		
1937–8	..	20	2	22
1938–9		20	2	22
		All Farms.		
1937–8	..	54	9	63
1938–9	..	49	14	63

groups the losses on the Cattle and Sheep (Better Land) has been heavy and out of 15 farms 8 showed losses. The Cattle and Sheep (Poor Land) group show 2 losses as against 1 in the previous year.

There has been some alteration in the frequency distribution of " farm incomes." Compared with 1937-8 more farms showed small profits of under £100, fewer farms showed profits of between £100—£300 and £301—£500 while the same number of farms showed profits of between £501—£700 in both years. Of the 9 farms which had unfavourable returns in 1937-8, six had losses of under £100 and of the 14 farms in 1938-9 nine showed losses of under £100. One farm in 1937-8 and 2 farms in 1938-9 showed losses of between £301—£500 but in both years there were no losses of over £500 recorded. (See Table VII).

TABLE VII.

Frequency Distribution of Profits (Farm Income).

	Profits.		*Losses.*	
	Number of Farms.		*Number of Farms.*	
Profits or Losses (Range)	*1937–8*	*1938–9*	*1937–8*	*1938–9*
	No.	*No.*	*No.*	*No.*
Under £100 ..	16	24	6	9
£101 — £300 ..	26	16	2	3
£301 — £500 ..	9	6	1	2
£501 — £700 ..	3	3	0	0
Total Farms ..	54	49	9	14

Of these 63 farms, two-thirds had a worse year in 1938-9 than in 1937-8, while one-third showed better returns. This distribution is of course associated with the different type-groups. The position for all farms and for the different type-groups is given in Table VIII.

TABLE VIII.

Increase or decrease in average "Farm Income" in 1938-9 compared with 1937-8

Type-group.	*Number of farms.*	*Increase or Decrease in Average Farm Income.*	*Number of Farms faring.*	
			Worse.	*Better.*
	No.	*£*	*No.*	*No.*
Cattle and Sheep (Poor Land)	16	—79.7	12	4
Cattle and Sheep (Better Land)	15	—94.1	13	2
Mixed Farms	10	—20.5	5	5
Dairy Farms	22	—1.2	12	10
All Farms	63	—46.4	42	21

The majority of the farmers in the Cattle and Sheep (Poor and Better Land) group experienced a worse year in 1938-9 than in 1937-8. Fifty per cent of the farmers in the Mixed Farm group found 1938-9 less profitable than 1937-8, while an equal number enjoyed better returns. The Dairy group showed a slightly higher proportion of farmers with poorer returns in 1938-9.

Table IX shows in addition to the 'farm income' the sum involved for occupiers' wages and interest on capital and the results on a further basis of 'labour income' and 'management earnings'. The labour income is farm income minus allowance for interest on capital at the rate of 6 per cent per annum and therefore represents the earnings of the farmer and his wife in manual labour and management on the farm. The 'management earnings' is the sum left over after deducting from the 'labour income' wages to the farmer and his wife for manual labour. The basis adopted for wages is to assess the full-time manual labour of an occupier at £90 per annum and a wife at £52 per annum.

When interest is allowed on capital at 6 per cent per annum the 'labour income' over all farms averaged 31s. 10d. per week in 1937-8 and 13s. 7d. in 1938-9. The results also indicate a decline in the 'labour income' in 1938-9 for all type-groups. The 'labour income' in the Cattle and Sheep (Poor Land) was 35s. 10d. in 1937-8 and 4s. 9d. per week in 1938-9. On the Mixed Farms it averaged 19s. 7d. per week in 1937-8 and 11s. 7d. in 1938-9 and on the Dairy Farms the 'labour income' averaged 58s. 4d. per week in 1937-8 and 56s. 9d. in 1938-9. There was a deficit in the 'labour

TABLE IX.

Farm Income, Labour Income and Managerial Earnings in £'s per Farm.

Year	*Farm Income.*		*Interest on Capital at 6 per cent.*		*Labour Income.*		*Allowance for Wages to Farmer and Wife.*		*Managerial Earnings.*	
	1937–8	*1938–9*	*1937–8*	*1938–9*	*1937–8*	*1938–9*	*1937–8*	*1938–9*	*1937–8*	*1938–9*
Type-group :	£	£	£	£	£	£	£	£	£	£
Cattle and Sheep (Poor Land)	144.0	64.3	50.9	51.8	93.1	12.4	86.6	86.6	6.5	74.2*
Cattle and Sheep (Better Land)	85.9	8.2*	93.9	93.2	8.0*	101.4*	55.2	55.0	63.2*	151.4*
Mixed Farms	135.7	115.2	84.7	84.9	51.0	30.3	75.8	68.4	24.8*	38.1*
Dairy Farm ..	215.3	214.1	63.6	66.5	151.7	147.6	68.2	67.0	83.5	80.6
All Farms	153.8	107.4	71.0	72.0	82.8	35.4	71.0	69.4	11.8	34.0*

*Minus Quantities.

income' of the Cattle and Sheep (Better Land) farms to the extent of £8 *per farm* in 1937-8 and £101.4 *per farm* in 1938-9.

In three out of the four type-groups the average 'labour income' in 1938-9 was inadequate to meet the cost of wages to the farmer and for his wife at the rate of £90 and £62 per annum respectively for actual time engaged in manual labour. The deficit was largest on the Cattle and Sheep (Better Land) and least on the Mixed Farms, and only the Dairy Farms were able to show 'managerial earnings' in both years (32s. per week in 1937-8 and 31s. per week in 1938-9). For all farms together the average 'managerial earnings' was 4s. 6d. per week in 1937-8 but in 1938-9 there was a deficit of £34 *per farm* to meet charges for wages to the farmer and his wife for manual labour at the rates already stated.

As already stated the farm income over all farms averaged over 5s. per acre less in 1938-9 and a decline is recorded for each of the type-groups. The fall was heaviest in the Cattle and Sheep (Better Land) group.

On the income side receipts from cattle, sheep, poultry, horses and crops declined while there have been increases in milk, pigs and miscellaneous receipts. Compared with 1937-8 there was an over-all decline in gross receipts on these 63 farms of £9.4 per farm or 2 per cent. The fall in gross receipts was heaviest on the Cattle and Sheep (Better Land) farms where an average decline of as much as 16 per cent occurred. The fall in sales of cattle and in particular of sheep appear to be responsible for this decline. At the other extreme gross receipts were higher in 1938-9 by 11 per cent on the Cattle and Sheep (Poor Land). For this type-group there was a substantial increase in the receipts from milk and some increase from sales of pigs, poultry and eggs while sales of cattle and sheep remained at about the same level in both years.

Over all farms there was a rise of 19 per cent in the receipts from dairy produce. This was entirely due to an increase in the sales of milk as receipts from other dairy products fell in 1938-9. The total quantity of milk sold rose by 13 per cent and the average price increased by slightly less than 13 per cent or by about 1½d. per gallon. With butter the quantity sold fell by nearly 16 per cent but the average price improved by slightly over one penny per lb. in 1938-39.

With cattle there is a wide variety of grades and qualities of cattle sales (e.g. veal, stores, mature beef, milch heifers and cows, fat cows, barreners, etc.). It is difficult to distinguish clearly between these different categories and to measure qualitative changes which may, in fact, have considerable influence on gross incomes. A change in average price per head of animals sold or bought may be due either to qualitative alterations or to variations in market prices, or to a combination of both factors.

The receipts from cattle (¹) fell in each of the type-groups in 1938-9 and especially on the Mixed Farms where the decline was as much as 24 per cent. Over all farms receipts fell by 14 per cent. This fall appears to be due not only to a reduction in the number of cattle sold but also to a drop in prices. Total cattle sold declined in numbers by slightly over 10 per cent while the average price realised per head (all cattle) fell by nearly 5 per cent. Over all farms the proportion of dairy cows, 'other' cattle and calves to total cattle sold remained practically the same in both years.

Receipts from sheep and wool declined by 17 per cent and was heaviest in the Cattle and Sheep (Better Land) group where receipts fell by 27 per cent. While the number of sheep sold (over all farms) rose by 7 per cent the average price realised per head for all classes of sheep sold fell by slightly over 21 per cent. The price of wool also fell and receipts from this source declined by 34 per cent. The receipts from pigs rose by 6 per cent and a rise in receipts was general for all type-groups except the Dairy Farms where a fall of 5 per cent was recorded. The rise in income from pigs is due wholly to an increase in output as the average price realised per pig (all classes) sold off these farms is slightly lower in 1938-9. The price comparison is rather unsatisfactory as the records do not indicate the proportion of pigs sold as forward stores, porkers and baconers. For sows and weaners (under 10 weeks old) the records indicate some improvement in the price realised per head sold in 1938-9.

Receipts from poultry and eggs showed over all farms a fall of 13 per cent in 1938-9 and this decline was common to all type-groups except the Cattle and Sheep (Poor Land) farms where the gross income from poultry and eggs rose by 23 per cent. The general decline which is noticeable over all farms is due to a quantitative reduction in output as the price of eggs rose by early ¾d. per dozen while the price of poultry sold per head remained at the same level in both years. Over all farms the mean number of hens was 9 per cent less in 1938-9, but the contraction in poultry stocks appears to have been most severe in the Dairy type-group where the mean number of hens was 20 per cent less than in the previous year. The records also indicate on the whole, a lower egg production per hen in 1938-9.

The number of poultry sold (all categories). in 1938-9 was about 10 per cent less than in the previous year while the number of eggs sold fell by nearly 20 per cent. As a result of better marketing facilities egg prices are highest on the Dairy Farms

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[1] Which includes payments made in respect of beef subsidy.

while production is heaviest on the Dairying and Mixed Farms.

Receipts from crops (which include payments made in respect of subsidies) are of minor importance and over-all farms only averaged £22.7 per farm in 1937-8 and £20.7 per farm in 1938-9. In both years the major part of the income from crops was obtained from sale of cereals (mainly wheat) potatoes and clover seed. Some changes are noticeable both in the quantities sold and the income from the various crops. The quantity of wheat and oats sold was greater in 1938-9, but there were no sales of barley in that year. The income from potatoes, roots and fruit rose in 1938-9 while the income from straw, hay, clover seed and vegetables declined.

The incidence of these changes differ in the four type-groups. The decline in receipts from cattle has been heaviest on the Mixed Farms ; from sheep and wool on the Cattle and Sheep (Better Land) group : from poultry and eggs on the Dairy Farms while the rise in income from pigs is most marked on the Cattle and Sheep (Poor and Better Land) groups. A rise in income from crops only occurs on the Cattle and Sheep (Better Land) group.

The changes in receipts already referred to have necessitated some alteration in the type and quality of materials bought. There has also been some variation in the unit costs of certain requirements. Over these 63 farms increases in outlay have occurred in rent, rates, wages, feedingstuffs, manures and new implements while decreases have occurred in seeds, sundry expenses and livestock purchases. Over all farms gross expenses (¹) declined by £22 per farm or by 3 per cent in 1938-9. Labour bills have tended to rise—the average increase being 2 per cent in 1938-9. This rise is most marked on the Mixed Farms where the labour bill rose as much as 8 per cent. At the other extreme there was a fall of 4 per cent in the expenses incurred on labour in the Cattle and Sheep (Better Land) group. Over all farms the average number of manual workers showed a slight fall in 1938-9. As a result of an increase in the average size of the farms covered, rents show a small rise of 3 per cent in 1938-9. Of type-groups, the Cattle and Sheep (Poor Land) farms showed no change, other type-groups show increases in rent and in the Mixed Farms the rise is as much as 10 per cent. Feedingstuffs is the largest single item of expenditure and over all farms there was a rise of 2 per cent in 1938-9. This is not general for all the type-groups as there was a fall in expenses of this nature on the Cattle and Sheep (Better Land) and Mixed Farms. Other type-groups showed increases and in the Cattle and Sheep (Poor Land) group the rise was as much as 57 per cent. As the price of feedingstuffs fell in 1938-9

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[1] Expenses include wages due or paid to family labour other than that of the farmer and his wife.

the rise in expenditure on purchased foods on these farms appears to be the result of larger quantities bought. Expenditure on fertilisers in 1938-9 was 18 per cent greater than in 1937-8, as a result of an increase in the quantities purchased. The principal increases occurred with basic slag and lime and this largely reflects the success of the Land Fertility Scheme. Partly as a result of the decline in arable land the expenditure on seeds fell (over all farms) in 1938-9 while larger purchases of new equipment resulted in a rise of 18 per cent on implements. Expenditure on purchased livestock declined in 1938-9 chiefly as a result of a drop in numbers and prices of horses, cattle and sheep bought. There was an increase in the number and price of pigs but all other classes of livestock (except chicks) over all farms declined in number and price. The incidence of these various changes in expenses differ between one type-group and another. The fall in expenses averaged 9 per cent in the Cattle and Sheep (Better Land) group where also receipts declined by 16 per cent. At the other extreme expenses rose by 5 per cent in the Cattle and Sheep (Poor Land) and receipts rose by 11 per cent. The expenditure on feedingstuffs increased only on the Cattle and Sheep (Poor Land) group (57 per cent) and the Dairy Farms (8 per cent) while the rise in expenditure on fertilisers was most pronounced in the Dairy (37 per cent) and the Cattle and Sheep (Better Land) groups (20 per cent). Increases on purchases of new implements only occurred on the Mixed and Dairy Farms. Contrary to all other type-groups expenses incurred on purchases of cattle rose and on pigs declined in the Cattle and Sheep (Poor Land) group.

AGRICULTURAL WORKERS' BUDGETS.

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Statements of income and expenditure of agricultural workers' households have proved more difficult to obtain than have similar data for industrial workers. Consequently information on standards of living of urban dwellers is much more complete and the statistical analyses much more detailed than in the case of agricultural workers. There also seems to be greater variation in the economic status of the industrial workers as a class and some budget studies have sought to illustrate the variations in the expenditure on foodstuffs and on other goods by households in different income groups. In the case of agricultural workers, however, the budgets almost invariably have been presented simply as the average for a number of households or given singly as representing typical cases. But it is known that variations do exist in the standards of living of groups of agricultural workers due to differences in income, in size of household and in the number of supplementary earners. In the present study an attempt is made to illustrate the influence of some of these factors on the food and general consumption of the households to which the data refers.

The budgets were collected in Lincolnshire in the Spring of 1937 by the National Union of Agricultural Workers and were forwarded to the Department (1) by an official of the Union. At that time the minimum rates of wages for adult male workers in the Holland division was 35 shillings per week and 32 shillings in Kesteven and Lindsey. Higher rates were of course payable to "special class" workers, while for various reasons some workers failed to obtain the minima mentioned.

In all 242 budgets covering one week's expenditure were forwarded but on examination it was found that in a number of cases important items of expenditure were not furnished, while in others the head of the household, although normally following agricultural employment, was temporarily unemployed during the week in question. These households had therefore to be excluded. Of 38 households containing one or more supplementary earners only 9 gave particulars of total household income, and these budgets have been tabulated separately.

The main analysis, however, is based on the returns for 169 households where the head—an agricultural worker—was in employment, and which did not contain any supplementary earners. The total number of persons in these households was 722 so the average size of household works out at 4.27 persons. These households, moreover, have been divided into groups on the basis of average income per person, which is obtained by dividing the household income by the number of persons in each. In a fairly homogeneous group such as the one under consideration it is apparent that this classification also sub-divides the households in a very general sort of way according to the number of persons they contain.

In Table 1 the proportionate expenditure on various items of expenditure is set out.

In all studies of budgets of working class households a great deal of emphasis is laid on the expenditure on foodstuffs. This is so because of the large proportion of the family income which is expended on food, and also in view of the intimate connection between the dietary and the general standard of living of the people. It is apparent, moreover, that the proportion of income spent on food is an important consideration, as decreasing proportionate expenditure on foodstuffs leaves a wider margin for the enjoyment of certain optionals and novelties which are the outward features of a standard of living.

It will be observed from the Table that food represents the most important single class of expenditures and averages 62.8 per cent over the whole group. It may be opportune at this stage to point out that " food " includes expenditure on an inclusive item termed " Groceries", a small proportion of which does not represent expenditure on foodstuffs. But this error is offset by the cost of certain home-produced foodstuffs for which no charge has been allowed. The tendency for the proportionate expenditure on food to decline with increase in income is well brought out although the actual amounts expended increase. In the lowest income group food claimed more than two-thirds of total expenditure and did not fall below one-half in any group.

These percentages are considerably higher than corresponding figures obtained from recent investigations of urban and industrial groups, although very high proportions have been recorded in previous surveys for households in poor circumstances. Thus in the case of the so-called unskilled labouring classes of both urban and rural communities as much as 70 per cent has been recorded as having been spent on food, and even then the food has, in some instances, been deemed insufficient to meet the nutritive requirements of the family. In a study of the diets of the labouring classes in Glasgow (2) made in 1921 as much as 80 per cent of income was spent by certain families on food, while in the case of Mr. B.

TABLE I.

Proportionate Expenditure on All Items by Income Groups.

Income per Person per Week	*Under 5s.*	*5s.—7s. 5d.*	*7s. 6d.—9s. 11d.*	*10s.—12s. 5d.*	*12s. 6d.—14s. 11d.*	*15s.—17s. 5d.*	*17s. 6d. & over*	*Whole Group*
	%	%	%	%	%	%	%	%
Food	68.5	64.8	62.1	63.2	56.3	59.9	59.3	62.8
Rent and Rates	12.7	11.9	12.2	11.8	12.9	11.7	11.9	12.2
Coal and Light	11.0	11.1	11.6	12.3	13.5	11.7	12.1	11.7
Clothing and Footwear	2.4	4.9	5.2	3.9	7.6	6.0	6.0	4.8
Clubs and Union	3.6	4.3	4.1	5.6	6.5	5.9	5.9	4.8
Instalments, etc.	0.9	1.6	2.8	1.7	1.3	1.6	1.8	1.9
Insurance	0.7	1.1	1.1	0.9	0.5	1.3	1.2	1.0
Other Expenditure	0.2	0.3	0.9	0.6	1.4	1.9	1.8	0.8
Total	100.00	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Seebohm Rowntree's (3) study of farm workers' budgets during 1912-13 percentages in the region of 70 were constantly recorded. At the other extreme the corresponding proportions as illustrated in the budgets of the well-to-do middle-class families nowhere approach such dimensions. That for the median family in a study made by Mr. D. Caradog Jones (4) in 1928 was 42 per cent, thus leaving after the payment of other absolute necessaries quite an appreciable proportion for education, recreation, and other forms of expenditure. But in the case of the bulk of the agricultural group under review there was but scant opportunity for such indulgence. These proportions are higher than those for some of the industrial unemployed. According to a recent study conducted in the Rhondda Valley the proportionate expenditure on food by a group of unemployed households with no supplementary earners only amounted to about 49 per cent, while the average for the total sample containing both employed and unemployed was about 45 per cent.(5) It was known, however, that agricultural workers have been under the necessity of using higher proportions of incomes for purchase of foods although the kind of standard which they seek to enjoy is shown by the tendency for the proportionate expenditure on food to decrease as the income at their disposal increases.

Rent and rates accounted for between 11 and 12 per cent of total expenditure in all the income groups. Of the 169 households in the main analysis, 53 lived in tied cottages for which the rent was 3 shillings per week. Expenditure on coal and light was next in order of importance and varied between 11 and 14 per cent. These two items are the most important forms of expenditure in the non-food group and constitute 64 per cent of such expenditure for the 169 households. Clothing and footwear accounted for only 4.8 per cent of total expenditure over the whole group and showed a tendency to increase with increasing income. This is a very much lower proportion than that shown in studies of working class households in urban communities. But it seems that quite a considerable amount of the sum recorded as having been spent on "Clubs" really signifies expenditure on clothing. Expenditure on the remaining items account for very low proportions of total outlay.

The proportionate expenditures on these items by the 38 households for which no details of income are available are almost identical with the averages for the larger group set out in Table I.

The amounts expended by the households in this sample were not covered by immediate cash income received although the deficit in the case of the 169 households only amounted to 3s. 8d. per household. Complete identity between income and expenditure (and saving) is seldom achieved in household budget studies and it is certainly not surprising that they do not balance in this case. Many of the households in the group under consideration were on their own admission unable to maintain their meagre standard of living on the amounts they received each week. A large number stated that they could not keep out of debt and others met the rent and paid for clothes out of overtime or casual earnings. No fewer than 99 of the chief earners of the households were "stood off" during wet and slack times while a few took on "odd jobs" at night. It is not surprising therefore that so many of the wives go out to work in order to supplement the earnings of their menfolk.

Information on expenditure on the chief kinds of foodstuffs by households in different income groups and on the size of these households is given in Table II. It will be observed that there is a pro-

TABLE II.

Expenditure on Foodstuffs per Person per Week by Income Groups.

Income per Person per Week	*Under 5s.*	*5s.—7s. 5d.*	*7s. 6d.—9s. 11d.*	*10s.—12s. 5d.*	*12s. 6d—14s. 11d.*	*15s. 17s. 5d.*	*17s. 6d. & over*	*Whole Group*
No. of Households	14	46	39	34	6	7	23	169
No. of Children	91	171	80	40	2	—	—	384
Total Persons	119	263	158	108	14	14	46	722
Average size of Household	8.50	5.72	4.05	3.18	2.33	2.00	2.00	4.27
	s. d.	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*
Bread and Flour	0 10½	0 11½	1 0¾	1 3¾	1 3¾	1 7	1 9	1 1
Meat	0 7¼	1 2¼	1 5	1 11	2 6½	2 5	3 5¾	1 5½
Milk	0 2	0 4	0 4¾	0 8¼	0 7	0 9¾	0 9½	0 5
Groceries	1 2½	2 0	2 6	3 3	3 6½	4 7½	4 8	2 5
Fruits and Vegetables	0 0½	0 1¾	0 7	0 3¾	0 6	0 7¼	0 7	0 3½
Total Food	2 10¾	4 7½	5 11½	7 5¾	8 5¾	10 0½	11 3¼	5 8

gressive increase in income per person with decrease in the size of household. The majority of the children are found in the lower income groups, the two lowest in fact containing almost 70 per cent of the total. Food expenditure increases with an increase in income per person, and especially so in the lower ranges. Purchases of the different kinds of foodstuffs also show the same trend. But whereas the actual sum spent on bread and flour increases from 10½d. in the lowest group to 1s. 9d. in the highest, the proportionate expenditure declines from 30.2 to 15.5 per cent respectively. The proportionate expenditure on meat on the other hand increases from 20.9 per cent in the lowest income group to 30.9 per cent in the highest. That on milk also shows this same general trend, but the proportionate increases are not so regular. "Groceries" as here defined constitute the most important single item of expenditure and account for between 42 and 46 per cent of total food expenditure in all groups. It may be recapitulated, however, that this item includes small non-food elements so that its importance is somewhat over-estimated. Outlay on fruit and vegetables on the other hand, has been under-estimated as that recorded only refers to purchases, whereas almost all the households in the sample had gardens and grew a good deal of the vegetables they consumed. Most of the households also kept fowls and quite a number kept a pig or two, although this custom is gradually dying out. The item "fruit and vegetables" may be taken as mostly fruit.

The 38 households with supplementary earners were somewhat larger than those in the main group, containing 4.68 persons. The expenditure on foodstuffs was also greater and averaged 6s. 3½d. per person. But there were no important differences in the make-up of the dietaries.

The chief results furnished by this analysis of food expenditure are the great differences in the sums expended by the households in the different income groups and in the make-up of the dietaries. The poorer households were unable to spend as much on food as the households in the higher ranges although it has been noted that their proportionate expenditures were considerably greater. In order to appease hunger these poorer households had to place relatively greater reliance on cheap bulky foods like breadstuffs, and were unable to consume as much of the body-building and protective foods such as meat, eggs, milk, fresh fruit and vegetables as the more favourably placed households. The food needs per head of these poorer and larger households are quite as great, and from the standpoint of the welfare of the growing generation, probably greater, than is the case with the smaller and better placed households, yet owing to lower income per head they are forced to satisfy their food requirements at a lower cost per head. This must result in a considerable reduction in the nutritive values and other satisfactions of the diet.

On the question of the adequacy of the diet it is not possible to make any hard and fast statements owing to the fact that the survey was not conducted with this object in view. But it is possible to compare the food consumption of the households in this sample with that obtained by a nation-wide survey which was concerned with the nutritional aspect of the dietary. This latter investigation was directed by Sir J. B. Orr and the results are published under the title "Food, Health and Income." In order to determine the adequacy of the diet in relation to income the population of Great Britain was divided into income groups on the basis of average income per head. The detailed statement given in Sir John Orr's report on the average expenditure on the different kinds of foodstuffs by households in different income groups has been summarised, in order to make it comparable with the very broad classification adopted in the present survey. This comparison is given in Table III.

The agricultural workers' households are slightly larger on the whole while their total food expenditure per head is also greater in all three income groups, thus showing their relatively greater dependence on foodstuffs in the sum total of their satisfactions than the average of all households in similar economic circumstances. The actual and the proportionate expenditure on bread and flour is also greater in the agricultural workers' households. It appears that the higher expenditures on foods and especially the higher expenditures on bread and flour by agricultural workers than by similar income groups is due to the greater food requirements arising from greater expenditure of muscular effort, work in the open-air and exposure to all the elements of weather.

Other comparisons may be seen from the Table.

It may be pointed out that the purposes of these two surveys and the methods adopted differ in certain important respects. The chief purpose of the present survey was to obtain information on the food consumption and general expenditure of agricultural workers' households from a limited sample from one English county. Sir John Orr, however, set out to determine the adequacy of the diets of households in different income groups on the basis of total supplies of foodstuffs available for human consumption in Great Britain supplemented by data from recent household budget studies. While it is therefore not possible to make strictly accurate observations on the adequacy of the diets of the agricultural workers' households some general indications may nevertheless be obtained.

Sir John Orr has written as follows on the diets of the households in the different income groups:

> "An examination of the composition of the diets of the different groups shows that the degree of adequacy for health increases as income rises. The average diet of the poorest group, comprising 4½ million people, is, by the standard adopted, deficient in every constituent examined. The second group, comprising 9 million people, is adequate in protein, fat, and carbohydrates, but deficient in all the vitamins and minerals considered. The third group, comprising another 9 million, is deficient in several of the important vitamins and minerals. Complete adequacy is almost reached in group IV, and in the still wealthier groups the diet has a surplus of all constituents considered." (6)

TABLE III.

Expenditure on Foodstuffs per Person per Week by Income Groups.

	Sir J. B. Orr's Survey			*Present Survey*		
	Group I	*Group II*	*Group III*	*Group I*	*Group II*	*Group III*
Income per Head per Week	Up to 10s.	10s.—15s.	15s.—20s.	Up to 10s.	10s.—15s.	15s.—20s.
Average size of Household	4.19	4.14	4.12	5.45	3.05	2.00
	s. d.	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*
Bread and Flour	0 9	0 11	1 0½	0 11½	1 3½	1 8¾
Meat	1 1½	1 7¾	2 2	1 1½	2 0	3 2¾
Milk	0 4¾	0 7½	0 9½	0 3¾	0 8¼	0 9½
Groceries	1 2½	1 11¾	2 10½	1 11¾	3 3½	4 7¾
Fruit and Vegetables	0 6¼	0 10	1 1½	0 3	0 4	0 7
Total Food	4 0	6 0	8 0	4 7½	7 7¼	10 11¾

Total food expenditure by the lowest group of agricultural workers' households is sufficiently near to that of the corresponding group in Sir John Orr's study that the same general observations may be applied to it. If the diet of the second group of agricultural households is such as to lie outside the scope of the nutritionists' criticisms of that of the corresponding group for the whole country, it is certainly not sufficiently satisfactory as to make it immune from the criticisms levelled at the diet of Group III. The diet of the third group of agricultural workers' households is probably adequate although it should be noted that it is just these households which do not contain any children. It is, to say the least, singularly unfortunate that the households with children are those which are unable to provide themselves with a satisfactory diet.

Such, then, are the chief features of the food consumption and general living conditions of the agricultural workers' households in the present sample. Of the values which enter into their standard of living, food is by far the most important. Yet in the majority of the households it is probable that the diet is insufficient to meet their nutritive requirements. In this and in previous consumption studies it was found that from the point of view of demand for foodstuffs and the constitution of the dietary the income of the head of the household is not the most important factor. The controlling factor is income per head of the family or household and it is for this reason that the food consumption of these households has been expressed on a per person basis. Households tend to be poor largely because of the number of persons they contain.

Now that this country is at war it is important that the living standards of agricultural workers should not suffer any deterioration but should, on the other hand, be improved. The increase in the minimum rates of wages is a healthy sign, although much of this may be termed a cost of living bonus. In a recent book on food supply during war-time it is stated that "the war policy should be based on the physiological needs of the population," and again "that the improvement in national diet and national efficiency should be maintained, even during the war." (7) Yet these writers admit that the households in the lower income groups could not afford to buy the amounts of rationed foodstuffs even in peace-time when prices were lower, and that these poor households are to all intents and purposes rationed by price. Without drastic changes in dietary habits, which may have to be shared by other classes, it is very difficult to see how the diet of these households may be brought up to physiological requirements during the present war conditions when there was inability, and apparently no urgent desire to give them an adequate diet in peace time.

The question of the satisfaction of food requirements is complicated by the present class structure of society, and it is these class standards of consumption which would have to be modified in order to raise the standards of living of the households in the lower income groups up to the optimum level. With a classless society the estimate of allocations of given amounts of foodstuffs would be relatively simple. A stratified society introduces many complications as a given increase in supplies would not have to be allocated between the different social classes in proportion to changes in supplies, but also in proportion to needs. It must be acknowledged however, that if certain classes are on a higher consumption level than others, and if no detriment is done by that higher consumption, then failure to provide for such consumption by the lower classes is a real deprivation.

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References.

(1) DEPARTMENT of Agricultural Economics, University College of Wales, Aberystwyth.

(2) A. M. T. TULLY : A study of the Nutrition and Economic Condition of Working-Class Families in Glasgow in April 1921 (*The Lancet*, July 2nd, 1921).

(3) B. SEEBOHM ROWNTREE and MAY KENDALL : How the Labourer Lives. London, 1913.

(4) D. CARADOG JONES : The Cost of Living of a Sample of Middle Class Families. (*Journal of the Royal Statistical Society*, May, 1928).

(5) This Journal, Vol. 13, pp. 81-93, Vol. 14, pp. 91-103., Vol. 15, pp. 29-42.

(6) Sir J. B. ORR : Food, Health and Income, London, 1936, page 49.

(7) Sir J. B. ORR and DAVID LUBBOCK : Feeding the People in War-time, 1940, p. 24 and p. 34.

COSTS OF TRACTOR WORK.

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Since the outbreak of the present war there has been a very considerable increase in the number of tractors in use on farms in Wales. This has caused some displacement of horses—a process which seems likely to occur to an increasing extent in the future until a good deal of the farm work is done with the aid of tractors. This innovation will have some far reaching effects on the organisation of agricultural operations and upon the planning of farm work generally. In view of the comparatively small size of farms in Wales, the acquisition of a tractor is relatively more important than on the larger farms of England. The average Welsh farm is normally equipped with about two to four working horses and numerous small horse-drawn implements. A tractor is capable of doing a considerable amount of the seeding and harvesting work on the arable land, together with some of the hay harvesting, barn and farm yard operations, but it is unlikely that it will enable farmers to dispense with horses altogether. Fields are comparatively small and many farms are hilly and these conditions often make tractor work extremely difficult or call for high degrees of skill in operation.

If farmers are to obtain sufficient tractor machinery to perform all farm operations considerable expenditure on new equipment will be essential and many of the present horse-drawn implements will become obsolete. Farmers may have to resist the temptation to sink capital in unproductive equipment. On small farms such expensive tractor equipment might be lying idle for a large part of the year with the result that it would not earn its cost. In earlier years farmers sometimes attempted to utilise existing horse machinery by coupling them together for use behind a tractor, but in general this did not prove very successful.

The rise in farm wages and the shortage of labour also necessitate the fullest use of man power. Normally the use of mechanical power enables farmers to increase the output of workers and to-day it is more than ever necessary to raise the productivity of labour in the interests of both the farmer and of the country. And this factor is of equal importance where, as in Wales, a good deal of the labour is performed by members of the farm family who are not usually remunerated on a wage basis.

With the increase in the work of arable cultivation in recent months, many farmers in Wales have purchased new tractors with the necessary machinery, whereas others have employed ploughing contractors. The costs of doing the various operations, however, show some appreciable variation from farm to farm. This is due to a variety of factors, the more important being the nature of the land cultivated, the size of fields, and the proportion of idle to working time. The more fully a tractor is worked, the lower in general is the cost per hour of work or per acre of land cultivated as certain overhead costs, such as depreciation, do not vary directly with the amount of work undertaken.

TABLE I.

Average Area covered yearly per Tractor.

Mainly pre-war period.

Operation	*Farmers' Tractors*	*Contractors' Tractors*	*All Tractors*
	Acres	*Acres*	*Acres*
Ploughing	51	245	148
Cultivating	19	29	24
Disc Harrowing	6	22	14
Seed Drilling	8	8	8
Harrowing	57	59	58
Corn Binding	41	37	39
Rolling	26	13	19
Other field work	31	57	44
TOTAL	239	470	354

Recent enquiries in Wales have revealed the great difference in the amount of work done between farmers' and contractors' tractors as displayed in Table 1. Although several farmers who have tractors undertake some ploughing for neighbours, on the average the amount of field work done by farmers' tractors is comparatively small and much below that done on the larger farms of England. It is true that tractors are quite extensively used for stationary work, in fact some farmers consider that barn operations justify the acquisition of a tractor quite as much as the field work. The average area covered per tractor, apart from ploughing, is also comparatively small and this is so in the case of both contractors and farmers. The majority of farmers who employ contractors or give jobs to their neighbours' tractors are able to do most of the field operations, apart from ploughing, by the use of horses. In view of these peculiarities many tractors are only employed for a part of their possible working time. This state of affairs, however, may to some extent be remedied in time as tractors gradually replace horses in other operations besides ploughing.

TABLE II.

Days worked per annum per Tractor.

Operation	*Farmers' Tractors*	*Contractors' Tractors*	*All Tractors*
	Days	*Days*	*Days*
Ploughing	18	71	44½
Cultivating	3	2	2½
Disc Harrowing	1	3	2
Seed Drilling	1	1	1
Harrowing	5	5	5
Corn Binding	5½	6	6
Threshing	1½	—	0¾
Rolling	2	1	1½
Other operations	4	7	5½
Indoor operations	18	17	17½
TOTAL	59	113	86¼

The ratio of actual to potential working days is really more important to contractors than to farmers. Contractors, unless they also run farms, frequently have difficulty in finding alternative employment for the men, farmers, on the other hand, do not suffer greatly in consequence of idle tractor time as in general no direct financial outlay is incurred upon the tractor during such periods. There are, however, many operations which could be undertaken on farms in Wales by the use of tractors in order to avoid idle time. Notably, there are grubbing up bushes, removing hedges so as to make larger fields, and mole draining.

The problem of ascertaining the cost of performing the various operations is complicated by the fact that contractors spend an appreciable amount of time in going from farm to farm, whereas this difficulty does not arise in the case of farmers. The distribution of time in the case of contractors has been found to be as follows :—

	Per cent
Actual working time	71.3
Road journeys	10.9
Adjustments to machinery	17.8
Total time	100.0

The time spent on road journeys may be comparatively high in Wales as farms are small and the average amount of work done per holding is somewhat low. In view of the smallness of the fields and the difficult stony ground often encountered in many parts of the Principality, the time spent on attention to the tractor and implements may also be above that found necessary under more favourable conditions. It is, however, important to note that in Wales the actual working time is under three-quarters of the total time during which tractors are engaged.

TABLE III.

Cost of Operations, per Acre.

Mainly pre-war period.

	Farmers' Tractors	*Contractors' Tractors*
	s. d.	*s. d.*
Ploughing ley......	12 4	11 1
Ploughing stubble	10 8	10 1
Cultivating	4 5	4 1
Harrowing	2 2	2 8
Corn Drilling......	4 7	3 0
Manure Drilling	4 4	3 0
Rolling	2 2	2 0
Corn Binding	5 8	4 9

The cost of performing the various farm operations will, of course, vary from place to place according to local conditions and from time to time with changes in costs of materials and labour. As all tractors for which data are available were taken into consideration, and these operate in various parts of Wales and under a variety of conditions—the figures in Table III should be fairly representative for the year ended April, 1940. Costs of operations by farmers' tractors are slightly higher in almost every case. This is principally due to a lower ratio of working to total time and possibly to less skill in manipulation. Tractor drivers in general show more skill in the work than farm hands who only operate a tractor at infrequent intervals. Contractors therefore are able to accomplish a given task in less time than farmers and it frequently happens that farmers devote more time to incidental work in order to improve the appearance of the jobs. The arts of arable cultivation are still important in the eyes of many farmers, even though tractors have replaced horses. The more attention given to the trimmings of the headlands, the cultivation of corners and similar work, the less in general the acreage covered per hour and the higher the cost of the operation.

Expenditures on oils and other materials vary in general in direct proportion to the amount of time the tractor is employed.

Certain items, however, are standing charges, and the more a tractor is used in the course of a year, the less heavy they are per acre of land covered or per hour of work. The depreciation charge on tractors has been allowed at the rate of 22½ per cent per annum and on implements at the rate of 10 per cent which are the rates fixed by the Inland Revenue Authorities. Depreciation is in fact the heaviest individual item entering into costs and amounts on the average to over one-third of the total. However, in the case of some tractors, which operate on the average for 170 days a year depreciation only amounts to one-fifth of total costs.

TABLE IV.

Distribution of Costs.

All Tractors.

	Per £ of Total Costs	*Per cent of Costs*
	s. d.	
Tractor Vapourising Oil	4 3	21.2
Petrol	0 9	3.8
Engine Oil	0 10	4.1
Gear Oil	0 3	1.3
Grease	0 1	0.4
Total Materials	6 2	30.8
Depreciation	7 7	36.9
Labour	4 5	22.9
Licences, Repairs and Renewals	0 7	2.9
Plough Shares	1 3	6.5
Total Others	13 10	69.2
Total All Costs	20 0	100.0

TABLE V.

Costs per Hour.

	s. d.	*% of Total*
Fuel Oils	1 1	25.0
Lubricating Oils	0 3	5.8
Depreciation	1 8	36.9
Labour	1 0	22.9
Others	0 5	9.4
	4 5	100.0

The average cost per hour employed at 4s. 5d. is comparatively high when compared with results under more favourable conditions in England. Again the cost per hour varies to some extent with the amount of work done The majority of the items which enter into costs vary directly with the amount of work undertaken, notably fuel, lubricating oils and labour, which together account for 54 per cent of total costs. Both oil prices and wages have risen lately and these have a considerable bearing on tractor costs as they are direct expenses and must, of course, affect the charges made for the hire of tractors.

The usefulness of tractors on farms in Wales, however, should not be measured entirely by the number of days employed or by the cost of performing the various operations. A tractor usually enables a good deal of the farm work to be done more quickly than is possible by the use of horses. Economy in the use of labour is therefore possible and this is of considerable importance to-day. The purchase of a tractor, however, especially on the smaller farms, usually necessitates some adjustment in the systems of farming. Keen farmers were usually able to arrange matters so that their work horses were really increasing in value every year. Young horses would be trained for farm work, they would appreciate in value at the same time and would be sold as prime draft horses. Under such conditions there was seldom any depreciation, but often some appreciation in value. A tractor on the other hand inevitably declines in value with advancing age, yet on the small farms its useful life may extend over a very long period and the annual rate of depreciation would really be very much lower than the rate normally allowed. Examination of recent experience with tractors on Welsh farms indicates that the economy of tractor work has been much higher than has generally been appreciated by farmers, and certainly higher than might be expected on theoretical grounds. Saving of manual labour, speed of accomplishment of work, quality of work, and low costs of depreciation of farm tractors carefully handled, may make comparisons between costs and results of horse and tractor work very favourable to the latter.

DISTRIBUTION OF PROFITS BY AGRICULTURAL CO-OPERATIVE SOCIETIES IN WALES.

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It is now almost a hundred years since the co-operative movement became firmly established in this country. It was in 1844 that the Rochdale Society of Equitable Pioneers was formed and from that year the movement made tremendous progress. Although there were several societies in existence prior to 1844 they were not truly co-operative as the idea of paying dividends on purchases, rather than on the capital invested, had not by that time been tried. The Rules of the Rochdale Society contained the novel clause that: " Interest at the rate of 3½ per cent per annum shall be paid upon all shares paid up previous to the quarter's commencement; the remaining profits shall be paid to each member in proportion to the amount of money expended at the store."

This clause introduced the method of paying dividends on purchases and amounted to a complete departure from the business technique in vogue up to that time. This type of co-operative society proved well able to withstand competition in trade as a study of the history of the last 100 years will show. Capital was relegated into a different category from that it had previously occupied and the importance of the trade done by individual members was given its due weight.

The movement had made great progress by the close of the 19th century; in 1900 there were about 1,500 retail distributive societies in the United Kingdom with a trade of some £50 million a year together with a large number of other societies. Almost throughout this period comparatively little control was exercised either by the State or by other authorities over the prices and supplies of goods handled by the societies. They were largely free to adopt their own policies in regard to the prices of the goods handled, some of this freedom, however, has been taken away in recent years and in consequence business policies have had to change. In earlier years much discussion centred round the question whether societies should charge comparatively high prices which would enable them to pay good dividends or whether the benefit of co-operation should be conferred on members through lower prices.

In later years especially since 1933 when societies became more liable to Income Tax, greater consideration has been given to the methods of dealing with profits than was formerly the case. The method of distributing profits which will confer the greatest benefits on members may vary from one set of circumstances to another and may need some close consideration. It might appear to be rather a simple matter to distribute profits and a more difficult one to earn them but a judicious distribution of profits should contribute to the strength and stability of a society and later add materially to its profit earning capacity.

A sound co-operative business must be supplied with adequate capital and historically it has been proved that there is a close relation between the profits made and the accumulation of capital. Many of the agricultural co-operative societies in Wales suffer from a shortage of capital. In several cases buildings are in need of renovation and new equipment is required yet difficulties are experienced in obtaining capital for these purposes. When capital is urgently required some societies have to resort to loans and other means when it could very well have been obtained from profits made in previous years had such moneys been more judiciously allocated. And in a few instances very large sums have been allowed to accumulate as unappropriated profits with the result that no effort is made to increase the share capital by enlisting new members.

TABLE I.

Distribution of Profits 1937 and 1938.

	Group 1. Sales under £10,000	*Group 2. Sales between £10,000 & £50,000*	*Group 3. Sales over £50,000*
	%	%	%
Income Tax	9.2	7.7	4.8
Share Interest	7.9	9.2	12.3
Staff Bonus	2.0	1.5	1.1
Dividends	64.0	69.5	72.6
Reserves	12.7	9.8	7.4
Others	4.2	2.3	1.8
	100.0	100.0	100.0

It appears that there is considerable variation in policies on the distribution of profits. A certain proportion of the total net profit is usually devoted to the payment of Income Tax, and the amount of this will largely depend on the proportions allocated to reserves and to the dividend. The incidence of this Tax is rather important; it tends to fall more heavily on the smaller and weaker societies as can be seen in Table 1. A newly established society is at a disadvantage, it is usually short of capital and must attempt to build up a reserve fund. An older society on the other hand, when its reserve fund is about equal to its share capital, may be comparatively free from the tax as it may distribute the bulk of its profits as dividends. The larger the proportion of its total profits that a young society allocates to reserves the more is it liable to the tax. A young society is always encouraged to build up its reserves as soon as possible as it may be necessary to draw upon them during years of adversity. In order to do this it may require to reduce the rates of dividends to members because it cannot often make larger profits per unit of goods handled by charging higher prices to customers. As all societies are more or less obliged to offer their goods at about the same prices it follows that the smaller ones cannot adopt a policy of high prices and large profits in order to be able to pay as good dividends as the larger societies. Reduction of dividend may reduce strength in competition or in attachment of members.

Interest on share capital is usually paid at the rate of 5 per cent; it is generally a first charge on profits and on the whole about 10 per cent of the net profits are used for this purpose. The increase of capital by share subscriptions or by the issue of bonus shares tends to increase the liability of a society towards its members and the additional interest that has to be met virtually amounts to an increase in the annual outlay. In consequence many societies have largely capitalised their businesses in other ways with the result that the increase in share capital has greatly lagged behind the increase in turnover. (See Table 2). Many have accumulated large funds of undistributed profits and have used them as the main source of capital as upon these no interest is paid. It is important to realise however that the accumulation of such large sums with a view to eventual distribution as bonus shares may not be in keeping with the provisions of the Prevention of Frauds (Investments) Act, 1939 as it may be interpreted as a policy of increasing proprietary rights or interests which is contrary to Clause 10 of the Act.

TABLE II.

Shares and Turnover of Requisite Societies.

	Number of Societies	*Share Capital per Society*	*Turnover per Society*	*Share Capital to Turnover*
		£	£	
1934	61	2,052	19,657	10.4
1935	60	2,124	22,053	9.6
1936	59	2,260	24,686	9.2
1937	58	2,723	28,629	9.5
1938	56	2,512	30,909	8.1

On the whole a very small proportion of net profits is distributed as a bonus to employees. The Rules of some of the societies provide that at least 5 per cent of the profits shall be distributed in this way but in many cases no such provision is made. Members appreciate that a contented staff is the greatest asset that a society can possess yet they do not realise that the payment of a bonus contributes greatly to this end. And it is noteworthy that the smaller societies devote the largest proportions of the net profits to this purpose.

TABLE III.

Distribution of Profits by Requisite Societies.

	Per Society						*Per cent of Sales*		*Per cent of Net Profits*	
	1937			*1938*			*1937*	*1938*	*1937*	*1938*
Distribution :	£	s.	d.	£	s.	d.	%	%	%	%
Income Tax	69	7	7	80	1	0	0.21	0.24	5.82	6.33
Share Interest	121	7	5	137	1	1	0.37	0.40	10.17	10.84
Staff Bonus	18	9	3	17	9	6	0.06	0.05	1.55	1.38
Dividends	725	10	0	869	1	8	2.24	2.56	60.86	68.72
Reserves	125	9	5	78	15	5	0.39	0.23	10.53	6.23
Others	41	7	4	13	12	11	0.13	0.04	3.47	1.08
Total distributed	1,101	11	0	1,196	1	7	3.40	3.52	92.40	94.58
Profit brought in from previous year	3,246	13	4	3,337	6	0	10.02	9.83	272.34	263.89
Profit in the year	1,192	3	8	1,264	13	6	3.68	3.73	100.00	100.00
Total available for distribution	4,438	17	0	4,601	19	6	13.70	13.56	372.34	363.89
Distributed	1,101	11	0	1,196	1	7	3.40	3.52	92.40	94.58
Carried forward to next year	3,337	6	0	3,405	17	11	10.30	10.04	279.94	269.31

The great bulk of the net profits is used in payment of dividends and in the case of the larger societies it exceeds 70 per cent of the total. Although at certain times the smaller societies are unable to pay good dividends yet they often strive to pay more than is really justified. A number of societies endeavour to secure some equalisation of dividends from year to year and during difficult business years it is quite common for the smaller societies in Wales to distribute between 15 per cent and 20 per cent more than has been earned, as they draw on accumulated profits of earlier years.

Members sometimes compare the rate of dividend paid on capital invested in a society with that available elsewhere and such comparisons may lead to fallacious conclusions, as co-operative societies are more concerned with a return on turnover than on capital. With an increase in the quantity of goods handled members

TABLE IV.

Size Group (Sales)	*1937* *Net Profits as % of* *Share Capital*	*1937* *Net Profits as % of* *Turnover*	*1938* *Net Profits as % of* *Share Capital*	*1938* *Net Profits as % of* *Turnover*
Under £10,000	31.4	2.7	32.7	2.9
£10,000—£50,000	57.1	3.2	56.8	3.4
Over £50,000	39.7	3.9	35.8	3.9
All Societies	42.7	3.3	41.7	3.4

normally expect a corresponding increase in the dividend. A business such as a joint stock company, which distributes its profit as interest on share capital can, with increasing sales, work on a narrower margin of profit and at the same time maintain the same return on capital. In the case of a co-operative society however the basis on which the dividend is paid increases in proportion to sales. In consequence it cannot reduce its margin of profit per unit of goods handled and at the same time maintain its dividend unless there is a corresponding fall in handling costs. If prices are lowered in order to enhance sales the liability for maintaining the dividend is increased although the return on capital is preserved.

Allocations to reserves really amount to a reinvestment of part of the profits in the business. Some societies however carry forward comparatively large sums from year to year as unappropriated profits and in fact such capital is extensively used for financing purposes. There is no advantage in adopting such a policy and the welfare of a society is better served by allocating the bulk of the moneys, not distributed as dividends or bonuses, to a reserve fund. A reserve fund cannot normally be drawn on so as to reduce it below the share capital. When a society has built up a fund equal to its share capital it is generally in a reasonably sound financial position. Unappropriated profits may be paid out as dividends or distributed in other ways at any time and such procedure might result in the weakening of a society to a far greater extent than would be possible were the money held in a reserve fund. The best policy for any society is to allocate part of its profits to reserve until the fund equals the share capital and subsequently to distribute as much as possible as dividends or as bonus shares. A society which obtains the great bulk of its capital from accumulated profits may tend to stagnate or even retrogress in the face of keen business competition. An increase in membership should normally accompany an increase in turnover and there are but few regions in Wales where an increase in membership is impossible.

SOME LEGAL AND POLITICAL IMPLICATIONS OF GOVERNMENT GUARANTEES FOR FARMERS.

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During periods of uncertainty confusion and disturbance many branches of British industry and agriculture turn to the Government with the object of obtaining some definite assurances or guarantees for the future. Such claims frequently emanate from those sections which have passed through years of depression. The revival of any important industry today may call for the expenditure of considerable capital, possibly the training of staff and in some cases the establishment of new statutory bodies for the purpose of undertaking the work of reconstruction. In some instances new industries have been set up under the *ægis* of the State, whilst subsidies and similar stimulants have frequently been provided. The rise of the beet sugar industry under the provisions of the British Sugar (Subsidy) Act, 1925, and subsequent Acts, is a good example of State assistance. Even in 1913 the Sugar Beet Growers' Society obtained a grant of about £11,000 from the Development Fund to aid experiments in the cultivation of the crop, and loans were advanced to the British Sugar Beet Society from the Development Fund in 1917, and later years whilst some remission of Excise Duty in 1922 helped to encourage the industry.[1] It was not until 1924, however, that the Government's decision to develop the industry was announced and a State subsidy on home-grown sugar was made available for a period of 10 years. In consequence, the industry gradually expanded during the subsequent decade ; the output of refined sugar which stood at only 23,000 tons in 1924-5 had risen to 615,000 tons by 1934-5.[2]

Attempts to control the prices of corn by legislation began in the Middle Ages and the English Corn Laws operated for some six centuries until the final repeal of the Acts in 1869. The objects were, *inter alia*, the establishment of " just prices " in the interests of consumers and the securing of reasonable profits for producers. Under the stress of the Great War the question of giving some form of assurance to producers of corn was again faced and the Corn Production Act, 1917, was mainly designed to encourage the growth of corn in this country by guaranteeing a minimum price for wheat and oats and to secure at the same time a minimum wage for agricultural labourers. Under the provisions of this Act producers of these two cereals were entitled to be paid by the Board of Agriculture such sums as would guarantee them minimum prices for the years 1917 to 1922 inclusive.

This policy of guaranteed prices was continued in the Agriculture Act, 1920. This Act was promulgated as embodying the Government's long period agricultural policy and it was intended that it should continue in force indefinitely. It provided, in fact, that the Corn Production Act, 1917, which was only a temporary measure, should continue in force until Parliament otherwise determined, but with power to His Majesty, by Order in Council, on an address presented to him by both Houses of Parliament, to declare that it shall cease to be in force on the expiration of the fourth year subsequent to the Order in Council. The 1920 Act, however, amended the 1917 Act in regard to prices of grain for 1921 and subsequent years, and guaranteed that minimum prices would subsequently be paid on the basis of costs of production. The Agriculture Act therefore attempted to give corn producers legal assurance that for an indefinite period guaranteed minimum prices would be paid for wheat and oats and that at least four years' notice would be given of any change of policy. The Act also gave tenant farmers additional security of tenure and continued the Agricultural Wages Board set up under the 1917 Act.

Although in the Agriculture Act, 1920, the Government had endeavoured to establish a permanent State policy for an important branch of British agriculture, this policy was abandoned in the first year of its operation. The Corn Production Acts (Repeal) Act, 1921, repealed the Corn Production Act, 1917, and also that part of the Agriculture Act, 1920, which (a) guaranteed minimum prices for wheat and oats after 1921, and (b) established the Agricultural Wages Board. Owing to the severe fall in cereal prices, the cost to the taxpayer would have been extremely heavy in later years, nevertheless compensation amounting to £18 million was paid for 1921 on the acreage of wheat and oats grown in that year. The country witnessed therefore a sudden and complete reversal of policy within a very short period. In 1920 the Government gave the most solemn assurance that was within its power to give and in the following year the same Government withdrew it completely.

In later years, however, various Governments have made other statements of policy and some of these have been embodied in Acts of Parliament. The Labour Government of 1924 re-established the Agricultural Wages Board under the provisions of the Agricultural Wages (Regulation) Act, 1924. Although originally set up in

1917, destroyed by the Repeal Act of 1921, the system of regulating wages was therefore revived in a modified form three years later and has survived many Parliaments during the last 16 years.

In recent years there has been a spate of agricultural legislation. Noteworthy have been the Agricultural Marketing Acts, 1931 and 1933, which are largely enabling measures. They have made it practicable for producers to mobilise themselves for group action in the markets of the country. Under their provisions commodity organisations have been established. The boards administering the Schemes are bodies corporate with a common seal and empowered to hold land without licence in mortmain. Under the financial provisions of the Schemes funds have been established, considerable assets acquired and enormous liabilities assumed on behalf of registered producers. It is obvious therefore that a repeal of the foundation acts would cause considerable disturbance as they form the legal basis for the operations of the Schemes established.

But remembering the experiences of 1921, which involved the abandonment of declared policy, farmers have often been disheartened. They had expected a continuation of that policy and an assurance that the promises made would be kept. And today farmers are again seeking an assurance from the Government that the prices of farm produce will be guaranteed at remunerative levels not only for the duration of the war, but also for an extended period afterwards. This question of guaranteed prices or in fact of giving any permanent assurance to a certain group of persons needs to be examined in relation to the nature of the Constitution. According to Dicey[3], one of the greatest authorities on constitutional law : " The sovereignty of Parliament is (from a legal point of view) the dominant characteristic of our political institutions. Parliament means the King, House of Lords and the House of Commons, and these three bodies acting together constitute Parliament. The principle of Parliamentary Sovereignty means that Parliament has the right to make or unmake any law and no person or body is recognised by the law of England as having a right to over-ride or set aside the legislation of Parliament." The unlimited legislative authority of Parliament was defined by Blackstone[4] as follows : " Parliament has sovereign and uncontrollable authority in the making, confirming, enlarging, restraining, abrogating, repealing, reviving and expounding of laws, concerning matters of all possible denominations, ecclesiastical or temporal, civil, military, maritime or criminal." This supreme legislative authority is clearly apparent from a study of some important enactments. Under the Septennial Act, 1716, Parliament extended its own life from three to seven years and under the Parliament Act, 1911, it limited it again to five years. Under the latter Act, however, the veto of the House of Lords on Money Bills has been abolished and on other bills reduced to a suspensive veto. Parliament can legally alter the status of an individual. Dicey[3] writes: " It may legitimate one that is illegitimate, or it may naturalise a mere alien and make him a subject born."

One writer has in fact summed up the matter in these words: " It is a fundamental principle with English lawyers that Parliament can do anything but make a woman a man and a man a woman." Under the English Constitution, which is largely unwritten, there is no distinction between constitutional or fundamental laws and ordinary laws. All laws are changed by the same body and in the same manner, namely, by Parliament acting in its legislative character. " The Bill of Rights could be cast overboard by the same process as the Rats and Mice Destruction Act, namely, by a repealing measure passed in the ordinary form."[5]

Certain writers have suggested that there are limitations to Parliamentary authority. Acts of Parliament, it has been asserted, are invalid if opposed to the principles of morality. It has also been maintained that the Crown possesses under the Prerogative a reserve of wide and indefinite powers and that this sovereign power is superior to the ordinary law of the land. Authorities on constitutional law, however, now consider these claims untenable. The third alleged limitation, which is very important, implies that one Parliament can legislate in such a way that the Acts cannot be repealed by any subsequent Parliament and that therefore the legislative authority of one Parliament may be limited by the enactments of its predecessors. Dicey[3] writes: " That Parliaments have more than once intended and endeavoured to pass Acts which should tie the hands of their successors is certain, but the endeavour has always ended in failure."

Parliamentary sovereignty is therefore an unquestionable legal fact. The reason for this is that a sovereign cannot while retaining its sovereign character restrict its own powers by any particular enactment. An Act, whatever its terms, might be repealed in a subsequent, or indeed in the same session and there would be nothing to make the authority of the repealing Parliament less than the authority of the Parliament by which the statute was enacted. It is clearly established therefore that Parliament is a body which can make or unmake any law and which therefore cannot be bound by any law.

In a broader political sense it is the electors which exercise sovereign powers. " The electors are the political sovereigns of the country, and in the end can enforce their will."[6] But the Courts will take no notice of the will of the electors except in so far as that will is expressed in or through an Act of Parliament. Nevertheless, the political is quite as important as the legal concept of the term.

It is generally conceded that the actual exercise of authority by a sovereign power is restricted by both external and internal forces. The authority of a government depends upon the readiness of the people to obey their behests. When force is on the side of the governed, governors have nothing to support them but opinion. This is the case in an effective democracy: in fact the legal sovereignty of Parliament is limited on every side by the possibility of popular resistance, moral or otherwise. Parliament therefore could not successfully embark on a policy which was contrary to the wishes of the bulk of the electorate.

The internal limit is particularly important in a democracy. It arises from the nature of the sovereign power itself. "The power of the legislature is limited from within because the legislature is the product of a certain social condition and determined by whatever determines the society."[7]

Though a sovereign power is bounded by these limits the boundary is rather indefinite. One peculiarity of representative government is that it tends to diminish the divergence between external and internal limitations. In other words, where the legislature truly represents the people, the wishes of Parliament cannot differ for any length of time from the wishes of the electorate.

The Constitutional position therefore needs to be taken very carefully into consideration when demands are made for government guarantees. It is conceivable that a government enjoying a large majority in the House of Commons may give an assurance that certain measures will be introduced during the life of that Parliament, in fact such assurances are always given and are embodied in the King's speech which is read at the opening of each session, and includes the government's plans for that session. No government, however, can do more than promise that certain bills will be introduced during the session: they cannot promise they will successfully pass through Parliament as, notwithstanding a possible veto by the House of Lords, the government themselves may go out of office before the life of the Parliament is terminated under the provisions of the Parliament Act, 1911.

Members of a political party, whether in office or not, frequently make far reaching promises to the electors that, if the party is in power, in the near future certain measures will be introduced. Mr. Neville Chamberlain, in fact, gave certain assurances:[8] He said in speaking of sugar beet: "I want to give you a definite assurance that the Government will take whatever steps are necessary to see that the crops, when grown, are harvested." Referring to prices of farm products, he used the following words: "My colleague, the Minister of Agriculture, said last December that if the increase in home production that we want is to be obtained, then the prices must be such as would give a reasonable return to the farmer and enable the farmer to pay a fair wage to the worker. I want to say that the War Cabinet endorse that declaration by the Minister of Agriculture."

In these two statements he was referring to measures which the Government would take during the period of the War and, of course, no constitutional difficulty can arise in their prosecution as the Defence Regulations[9] enable the Government to fulfil these undertakings. In regard to assurances after the War, the Prime Minister said: "It would be dishonest if I were now to give you a definite and specific pledge as to what will happen at the end of the War. I can only tell you what is in my mind now and I say this to begin with. The Government is determined, if they are in office, that agriculture will not a second time be allowed to collapse as it was last time. . . . If I can describe now what is in the minds of the Government, it is that conditions shall be made to continue after the War of such a character that they will allow farmers and workers to get a reasonable return from a reasonably conducted agriculture."

The Minister of Agriculture also dealt with the problem of guaranteed prices in a reply which he gave in the House of Commons to a question inquiring whether he would give an assurance for at least two harvests after the termination of the present hostilities that the agriculturist should receive such prices for his produce as would enable him to earn a reasonable profit and pay a fair rate of wages to his employees. He said:[10] "It is not possible to bind future Parliaments in advance and I am not at present in a position to say more than that the Government have kept in mind and will continue to do so, in formulating further plans, the special need in the case of the farming industry for confidence in continuing a policy inasmuch as the farming industry has to plan its production programme for several years ahead."

In regard to the matter of financial guarantees, however, it is also necessary to understand Parliamentary procedure in financial affairs. Chalmers and Asquith write[6]: "Public money cannot be raised or spent without the authority of Parliament." In fact, since 1911, the House of Commons has full control of finance, but financial legislation must proceed on the initative of the Government as the House of Commons cannot increase any financial provisions proposed by the Government. No private member may move a resolution to increase expenditure, although he may move to reduce it. The initation of expenditure is therefore entirely in the hands of the Government and no other member of the House of Commons is at liberty to move that any financial obligations be undertaken by the State.

In general all revenue is paid into the Bank of England on Government account and payments out are made as authorised by various statutes. The Treasury, of course, checks all expenditure so that no more money is spent than is clearly authorised by Parliament. This control, exercised by the Treasury, is very important and it frequently happens that the nature of the control granted to this body is clearly specified, with the result that any financial assistance given by Parliament for the prosecution of purposes embodied in a statute, is only paid out at the discretion of the Treasury. It may also happen that the Treasury may attach rather onerous conditions to any financial advances with the result that the assistance is of little practical value. The Agricultural Land (Utilisation) Act, 1931, contained many excellent clauses for the improvement of agriculture, including the provision of small holdings with financial assistance for unemployed persons and agricultural workers, it also empowered the Minister of Agriculture to acquire land for purposes of reconditioning. This Act also made available considerable sums of money for agricultural development, but in general such financial assistance was very largely under the control of the Treasury; in consequence, little filtered through to the farming industry. One clause of the Act reads: "The Treasury may, subject to such conditions as they may determine issue out of the Consolidated Fund of the United Kingdom or the growing produce thereof, such sums as may be required . . . . not exceeding £5 million." Another clause lays it down that "the Treasury may if they think fit, for the purpose of providing money for sums so authorised to be issued out of the Consolidated Fund . . . borrow by means of terminable annuities . . . . " And yet another clause reads "The powers of the Minister . . . . shall be exercised in accordance with such conditions as may after consultation with the Minister be prescribed by the Treasury."

It is clear that the initiation of any scheme of land development under this Act was dependent on the concurrence of the Treasury and by imposing onerous terms or attaching restrictive conditions on financial advances many of the provisions of the Act might be rendered entirely nugatory.

It is true in general that the Treasury exercises very close control over State expenditure and it is unlikely that Parliament will in future authorise any other body to exercise this jurisdiction, to the exclusion of the Treasury, over any funds that concern the whole community. In the case of the Wheat Act, 1932, however, a rather exceptional plan was adopted. Under the provisions of this Act a Wheat Fund was established into which is paid all the money received by the Wheat Commission from quota payments made by millers and importers and out of which all expenditure incurred by the Commission is defrayed. In fact, all matters relating to the Fund are regulated according to the provisions of the Act and to the bye-laws of the Commission made thereunder.

The Fund is administered by the Wheat Commission and under the provisions of the Act considerable sums are annually paid to wheat producers. And so long as the Act remains in force a subsidy will under certain conditions in regard to prices be paid to home producers of wheat and the levy will continue on certain classes of imports. This is therefore a case of an independent fund, it is self regulatory to some extent and in general the machinery set up under the Act has functioned very satisfactorily.

The method of obtaining money to provide assistance for a certain branch of farming may also take the form of an ' ear-marked ' tariff. This method, however, must not be confused with that adopted in the case of wheat. An ' ear-marked ' tariff implies that the money obtained by the imposition of import duties on certain classes of goods will be devoted in part or in whole to the payment of a subsidy on the native article of a similar nature.

The general plan envisaged by the Government in 1934 was outlined in a White Paper[11] on the subject, issued in that year. It stated that : " The Government have therefore examined the possibility of action along the lines of the Wheat Act, 1932, involving the collection of a levy on imports of meat to provide a fund from which payments could be made to supplement the returns accruing to home producers from the sale of their stock."

It is further stated that : " The Government are of opinion that a plan based on a levy which would be on all imported meat, including livestock and a regulated market . . . would afford the best long term solution of this problem. . . . Such a plan would establish under the control and management of a permanent Commission a fund into which would be paid in due course the proceeds of such a levy and out of which would be made such payments to producers of livestock in the United Kingdom as might be justified by the market situation and as might from time to time be determined."

Under such a plan, however, the money would not pass directly to a fund, from which the subsidy payment would be drawn, but would be handled in much the same way as other revenue. And the cattle subsidy as originally envisaged is a good example of this form of assistance. It was implied that the revenue obtained from a tariff imposed on certain meats would be used for the purpose of paying a subsidy on certain classes of livestock.[12]

The earlier Acts, however, were largely temporary measures passed to meet the exceptionally low prices realised by home producers of livestock. In 1936 the Ministry of Agriculture announced the Government's permanent proposals for safeguarding the livestock industry and these were later embodied in the Livestock Industry Act, 1937. This latter Act provides that there shall be paid into the Cattle Fund out of moneys provided by Parliament such sums not exceeding £5 million in the aggregate in any one financial year as the Ministers, with the approval of the Treasury, may from time to time determine. The moneys provided by Parliament for this purpose are voted as a grant in aid of the Cattle Fund.

The plan of an " ear-marked " tariff is really composed of two integral parts, i.e., the *collection* and the *distribution* of certain moneys ; and it is implied that the amount available for dispersion would be dependent upon the sum collected. Under such an arrangement home producers would of course run the risk of fluctuations in the amount of available assistance and to that extent such a plan would be of a rather hazardous character. It is doubtful whether any plan in this form has ever been applied in British Agriculture and it is extremely unlikely that it will be attempted. And it is also doubtful whether farmers in this country would welcome it, or be satisfied with it after experience, as it would not provide the assurances which they hope to obtain.

A plan of a semi-permanent character was embodied in the Bacon Industry Act, 1938, which was designed to place the whole bacon industry upon a stable and permanent basis. The machinery set up under the Act could only be amended or abolished by further legislation, but subsidies were payable for a period of three years. The Act itself established the Bacon Development Board as a body corporate and this places it in a different position from all the other agricultural marketing boards which are promoted and maintained by their registered producers. The latter may be revoked according to the provisions of the Agricultural Marketing Acts, 1931 and 1933, but neither the bacon nor the pig producers have power to set aside the Bacon Development Board. The subsidy voted to the industry was made available for three years, after which it was contemplated that the industry could proceed without State assistance. However, farmers were not satisfied. They sought an assurance over a much longer period, as they claimed that a ' permanent' policy involving financial assistance for this important branch of the agricultural industry should extend much beyond the three years laid down in the Act.

The question of government guarantees for farmers must therefore be viewed in relation to both the legal and political position. Parliament being a sovereign body cannot be bound, and cannot bind itself, and any Act which purported to guarantee prices might be repealed in the same or in any subsequent session. But, on the other hand, it would be politically impossible to legislate in violation of the wishes of the electorate. This is true in both a positive and negative sense; although Parliament cannot enforce enactments which are not supported by public opinion it must not neglect to carry out what the people desire.

It is of course possible for the present Government to give definite assurances to farmers for the duration of the War as extremely far reaching powers are embodied in the Defence Regulations. On the other hand, the Government cannot now undertake obligations extending beyond the War as they may not be in a position to fulfil them. The political implications of the problem are really of the utmost importance. Were the agricultural community able to convince the general body of electors that, in the interest of all, it was essential to maintain the agricultural industry in a sound financial position and that guaranteed prices were an integral part of such a plan they might achieve the end they desired. This position was, in fact, almost attained at the close of the Great War. At that time it was openly stated by various political leaders, at least for a short time, that never again would the agricultural industry of this country be allowed to languish; but that enthusiasm was allowed to fade. It is really for those who speak for agriculture to state and to fight the case for recognition as it is only by the exercise of the sovereign political power vested in the electorate that they can have guarantees from the government extending over a long period of time.

References.

1. Report of the Sugar Beet Industry at Home and Abroad. Ministry of Agriculture, Economic Series, No. 27. 1931.
2. Report of the United Kingdom Sugar Industry Inquiry Committee, 1935. Cmd. 4871. H.M. Stationery Office.
3. A. V. DICEY. "Law of the Constitution." 8th Edition. MacMillan and Co., London. 1931.
4. WILLIAM BLACKSTONE. "Commentaries." 15th Edition, 1809. Cadell and Davies.
5. E. C. S. WADE and G. G. PHILLIPS. "Constitutional Law." 2nd Edition. Longman Green and Co., London. 1935.

6. D. CHALMERS and C. ASQUITH. " Outlines of Constitutional Law." 4th Edition. Sweet and Maxwell, London. 1930.
7. LESLIE STEPHEN. " Science of Ethics." Murray, London. 1907.
8. Address to Chairmen of County War Agricultural Executive Committees, March, 5th 1940.
9. Defence (Agriculture and Fisheries) Regulations, 1939. H.M. Stationery Office.
10. *Hansard.* December 14th, 1939.
11. The Livestock Situation. Cmd. 4651. H.M. Stationery Office.
12. Cattle Industry (Emergency Provisions) Acts, 1934 and 1936. H.M. Stationery Office.

THE COST OF GRAZING ON WELSH FARMS.

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Since the year 1934-5 a scheme has been in operation for the purpose of determining the cost of milk production in England and Wales. As a result of this enquiry it is now possible to publish some aspects of the cost of grazing on some farms in Wales.

For the purpose of the present study eleven farms situated in South Wales have been selected because the farmers have kept records continuously over the period of four years, 1935-9. The total area covered by the eleven farms was 1,206 acres, 108 of which, or 8.9%, was under arable crops. Four of the farms were entirely under grass, while the proportion of arable to total area on the remaining seven varied from 1 to 27 per cent. The variety of size of farms was wide, the smallest being 42 acres and the largest being 420 acres.

On all farms the greater proportion of the receipts were derived from the sale of liquid milk, but other farm enterprises have been carried on in varying degrees. Seven of the farms kept appreciable numbers of cattle, sheep, horses, pigs and poultry, while the remaining four kept cattle and horses with only sufficient pigs and hens to supply domestic requirements. Over the whole group of farms for four years the average stock carried was as follows :—

	Total No.	*No. per Farm*
Dairy Cows	204	18.54
Feeding Cattle	15	1.40
Store Cattle	97	8.81
Calves	25	2.27
Sheep	365	33.18
Lambs	153	13.90
Work Horses	30	2.72
Other Horses	16	1.35
Pigs	4	0.36
Poultry	2,200	200.00

Methods of determining costs.

Co-operating farmers kept detailed records of the hours of manual, horse and other labour on pastures, the quantities of farm yard manure and artificial fertilisers applied, together with the number and classes of livestock grazing the pasture.

The hours of manual labour were charged at current rates of wages and horse labour was assessed at 4s. per working day of 8 hours. Farm yard manure was valued at 5s. per ton and artificial manures and other materials were charged at the actual costs on the farm, plus any charges for handling.

Charges for the grazing of meadow and seeds aftermath were assessed by reckoning aftermath to be worth one-third of the rental of the land set aside for hay production.

TABLE I.

Summary of Costs of Grazing, 1935-39.

(Per Acre.)

No. of Farms	11	11	11	11	11	—
Year	1935-36	1936-37	1937-38	1938-39	*Average all Years*	
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	%
Rent	1 5 0	1 4 4	1 4 11	1 4 0	1 4 6	63
Seeds	0 0 8	0 0 6	0 0 6	0 0 8	0 0 7	2
Manures	0 5 7	0 7 8	0 9 2	0 7 8	0 7 6	19
Labour:						
(a) Man	0 4 11	0 4 8	0 5 2	0 5 0	0 4 9	13
(b) Horse	0 1 8	0 1 11	0 1 8	0 1 10	0 1 9	3
Total	1 17 10	1 19 1	2 1 5	1 19 2	1 19 1	100
Cost per cow equivalent	4 19 0	5 3 3	4 18 11	5 4 7	5 1 2	—
or						
Cost per sheep equivalent	0 14 2	0 14 9	0 14 0	0 14 9	0 14 5	—
No. of acres per cow equivalent	2.67	2.64	2.39	2.67	2.59	

For the reason that pastures were grazed by dairy cows, fat cattle, store cattle, horses and sheep, etc., it was necessary to adopt some scale by which the different classes of stock could be expressed in terms of one type. For this purpose the following standard was used :—

1 cow = 1 work horse
or 2 other horses
„ 2 store cattle
„ 4 calves
„ 7 sheep
„ 5 breeding sows
„ 200 mixed poultry

By using the methods outlined the average cost of grazing for each year and the average for the whole period 1935-9 for eleven farms is given in Table I. The average cost of grazing amounted to £1 19s. 1d. per acre with variation from £1 17s. 10d. in 1935-6 to £2 1s. 5d. in 1937-8. Except in the case of manures the variations in items of cost over the group have not been great. Manures, however, range from 5s. 7d. per acre in 1935-6 to 9s. 2d. in 1937-8. Average costs for the whole period show that the rent amounted to 63 per cent, seeds 2 per cent, manures 19 per cent, and manual and horse labour together 16 per cent of the total cost per acre. Each cow on an average grazed 2.59 acres. Therefore in terms of animal units the cost "per cow" averaged £5 1s. 2d. and varied from £4 18s. 11d. to £5 4s. 0d. per annum. The cost of pasturage per "sheep equivalent" averaged 14s. 5d. per grazing year. Expressed in terms of "cost per week" the cost per cow averaged about 1s. 11d. and per sheep 3⅓ pence. If it is assumed that cows were out on grass for 26 weeks during the year the average cost of grazing per cow per week would be 3s. 10d. Sheep graze pastures throughout the year, but assessing the value of summer grazing at four times that of winter grazing the weekly cost of grazing per sheep would be 5.25 pence in summer and 1.3 pence per week in winter.

Variations in cost items.

In Table I it has been shown that the average cost of maintaining pasture for the whole of the eleven farms over 4 years was £1 19s. 1d. per acre. Although this is so, it must not be inferred that the cost per acre for each individual farm is somewhat similar. Table II shows that even in a small sample of farms the degree of variation in costs per acre is great : the lowest cost recorded being 18s. per acre for one farm in the year 1935-6, and the highest cost being £4 9s. 0d. per acre for another farm in 1938-9. However, taking the costs for four years, the greater proportion, 60 per cent, fall between 30s. and 50s. per acre.

TABLE II.

Farms Grouped by Total Cost per Acre.

Range in Costs per acre	1935-36 *No. of Farms in Group*	1935-36 *Average cost, per acre*	1935-36 *% of Total*	1936-37 *No. of Farms in Group*	1936-37 *Average cost per acre*	1936-37 *% of Total*	1937-38 *No. of Farms in Group*	1937-38 *Average cost per acre*	1937-38 *% of Total*	1938-39 *No. of Farms in Group*	1938-39 *Average cost per acre*	1938-39 *% of Total*	Average Four Years *No. of Farms in Group*	Average Four Years *Average cost per acre*	Average Four Years *% of Total*
Shillings.		£ s. d.			£ s. d.			£ s. d.			£ s. d.			£ s. d.	
10—20	1	0 18 0	9	1	1 0 0	9	—	—	—	—	—	—	—	—	—
21—30	2	1 6 6	18	1	1 4 9	9	2	1 3 1	18	1	1 5 9	9	2	1 3 9	18
31—40	2	1 12 8	18	3	1 14 10	27	4	1 14 11	37	3	1 13 9	27	3	1 15 10	27
41—50	4	2 6 1	37	4	2 6 4	37	1	2 5 3	9	6	2 2 10	55	4	2 5 2	37
51—60	1	2 13 2	9	1	2 16 0	9	2	2 14 8	18	—	—	—	1	2 13 8	9
61 & over	1	4 1 0	9	1	4 3 7	9	2	3 8 2	18	1	4 9 0	9	1	4 4 0	9

Rent.

Rent comprises almost two-thirds of the total costs and has remained practically unchanged over the four years ; the variation being from £1 4s. 0d. to £1 5s. 0d., or one shilling per acre. Rentals vary considerably from farm to farm. For example, in the present sample the lowest rental was 15s. 5d. per acre and the highest £3 9s. 6d. per acre, but variation in rentals cannot be discussed apart from consideration of many other factors such as type of land and location of the farm, etc. Cost of seeds is a minor item in grazing costs and amounts to the small charge of 7d. per acre or 2 per cent of the total cost of grazing.

Manures.

The variation in the average sums of money spent in manuring of grassland, especially with reference to artificial manures, is very striking. For the whole period the average cost of manures was 7s. 6d. per acre, but costs varied from 5s. 7d. per acre in 1935-36 to 9s. 2d. in 1937-38. As might be expected, the variations in the costs per acre of manuring are much greater for individual farms than these average figures reflect. For individual farms costs range from 4s. to 27s. 1d. The statement of quantities and costs of manures is given in Table III.

The quantity of farm yard manure applied varied from 15.9 cwts. per acre in 1935-6 to 24.3 in 1937-8 with a general average over the whole period of slightly over a ton per acre. Farm yard manure has been charged at a flat rate of 5s. per ton, therefore, costs have varied in accordance with the quantities applied. Mainly as a result of increased quantities applied the expenditure on other fertilisers increased each year as follows :—

	Total Cost of fertilisers (per acre).	
	s.	*d.*
1935-6	1	7
1936-7	1	9
1937-8	3	2
1938-9	3	7
All years	2	6

Lime and phosphates have been applied in widely different amounts over the whole group for the different years and much more so when considering individual farms. Much heavier dressings were applied in 1937-8 and 1938-9. This seemingly was encouraged by the facilities offered for the purchase of such fertilisers under

TABLE III.

Quantities and Cost of Farm Yard Manure and Artificial Manure.

(Per Acre.)

Year	*1935-36*		*1936-37*		*1937-38*		*1938-39*		*Average all Years*	
	cwts.	*s. d.*	*cwts.*	*s. d.*	*cwts.*	*s. d.*	*cwts.*	*s. d.*	*cwts.*	*s. d.*
Farm Yard Manure	15.90	4 0	23.82	5 11	24.30	6 0	16.74	4.1	20.19	5.0
Lime	0.71	0.10	0.55	0.4	2.47	2.0	1.68	1.7	1.35	1.2
Phosphates	0 15	0.6	0.57	1.3	0.43	0.10	0.85	1.9	0.50	1.1
Potash	—	—	—	—	—	—	0.01	0.1	—	—
Nitrogenous	—	—	0.01	0.1	0.03	0.4	0.02	0.2	0.02	0.2
Compound......	0.03	0.3	—	—	—	—	—	—	0.01	0.1
Total	—	5.7	—	7.8	—	9.2	—	7.8	—	7.6

the Land Fertility Scheme, 1936. If the average quantity of manure applied over the past four years is representative of longer periods it will be seen that such quantities would be sufficient for the following applications :—

10 tons of farm yard manure every 9th year,
10 cwts. of lime every 8th year,
2 cwts. of phosphates every 4th year,
Other manures negligible.

The results indicate that the farmers have taken advantage of the Land Fertility Scheme to obtain supplies of lime and phosphates at cheaper rates. While farmers fully realise the beneficial results of an application of nitrogenous manures as a means of securing earlier grazing in the Spring they possibly do not feel justified in buying manures of this nature at present prices.

Labour.

Manual and horse labour costs have remained fairly constant from year to year. Over the whole period they amounted to 6s. 6d. per acre. Of this amount 4s. 9d. per acre represented manual labour and 1s. 9d. per acre was horse labour. In Table IV details of the labour on pastures are summarised, giving the distribution of hours and cost over the different tasks. It will also be seen that each acre has been given on an average the labour of one man

TABLE IV.

Average Distribution of Labour, 1935-39.

(Per Acre of Total Pasturage Area.)

	Horse Days	*Cost*	*Man Days*	*Cost*	*Total Cost*	*% of Total Labour*
		s. d.		*s. d.*	*s. d.*	%
Farm Yard Manure	0.15	0 7	0.24	1 3	1 10	28
Artificial Manure	0.03	0 2	0.05	0 3	0 5	6
Total Manuring	0.18	0 9	0.29	1 6	2 3	34
Harrowing and Rolling	0.20	0 11	0.12	0 7	1 6	23
Ditching and Draining	—	—	0.12	0 7	0 7	9
Fencing and Hedging	0.01	0 0½	0.35	1 7	1 7½	25
Thistles and Stones	0.01	0 0½	0.09	0 6	0 6½	9
Total	0.40	1 9	0.97	4 9	6 6	100

for one day per annum and the labour of one horse for almost half a day per annum. Of the combined cost of manual and horse labour, namely, 6s. 6d. per acre, 2s. 3d. or 34 per cent has been used in manuring, 1s. 6d. or 23 per cent in cultivations—harrowing and rolling, 1s. 7½d. or 25 per cent on fencing and hedge work and the remaining 1s. 1½d. or 18 per cent on ditching and draining and the removal of weeds and stones. It is evident that, on the whole, the amount of labour expended on grassland is low ; and in the light of results obtained on certain individual farms it must be inferred that greater amounts of labour employed in cultivating operations and general management would amply repay other farmers.

Conclusion.

Reviewing the results as a whole it certainly appears that there is much scope for the improvement of grasslands. Farmers have been too inclined to confine the rotations of crops to a few fields within convenient distance of the homestead and to do little by way of improving the remaining fields of the farm. In a great number of cases old and worn-out leys could be advantageously ploughed up, seeded with rape and re-seeded with grass. In other cases much improvement could be effected by more frequent harrowing to break up the mat which is retarding active growth. Clover concentration would be greatly encouraged by more liberal application of phosphates and the herbage in general would derive benefit from more frequent applications of lime. The grazing season could be extended by the judicious use of top dressings with nitrogen.

Pastures cannot be well managed unless they are grazed closely and stock numbers should be sufficient to ensure this condition. But there are in practice times when it is impossible for stock to consume the grass as quickly as it is being produced and a surplus develops. At such times it would be advisable to run the mowing machine over the pasture in order to avoid the smothering out of the finer species by the coarser types which thrive in advanced conditions of growth. If the surplus grass removed in this manner is sufficient in quantity to warrant the additional work it can be turned into useful grass silage for feeding later in the season. The improvising of a silo for this purpose is comparatively simple.

A SUMMARY OF SEVEN YEARS' WORK ON VARIETIES OF SWEDE.

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Introduction.

Great difficulty has been experienced in assessing the comparative value of different varieties of swedes when grown under average farm conditions. It has been shown (1.2)* that even in the relatively simple matter of fresh weight of roots yielded per acre there are many factors such as a drift in fertility, or variations in the rate of sowing and singling, which obscure the results obtained in field trials. Above all, this work made it evident that the incidence of diseases, and not the variety grown, was usually the determining factor in the weight of useable roots lifted or taken out of storage ; though, of course, the amount of any particular disease found might be influenced by varietal susceptibility. Furthermore, it appeared from a study of the available literature that insufficient attention has been paid to other varietal characteristics such as yield of dry-matter per acre, rate of maturation of roots and their relative keeping power in storage, although these are certainly of importance in correctly assessing the real value of a swede variety to the farmer.

The Present Trials.

In 1933, therefore, new trials were initiated and have been continued up to the present (1940) season, with the object of attempting a classification of popular varieties of swedes which should take into account their reaction as to many as possible of these factors of agricultural importance.

(1) **Summary of Results obtained in 1933-1935.** During this period detailed observations and analyses of roots were made every three weeks or so, with three varieties, during the period October to February, and on three dates in October, December and February with nine other varieties. At the same time the keeping power of the twelve varieties was tested both in the field and after varying periods of storage in clamps. The most important of the results obtained may be summarised as follows :

(a) A reasonably accurate estimate of the percentage dry-matter of a crop can be made by taking ' cores ' at right angles to the axis from fifty roots in succession.

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*See References on page 106.

(b) The percentage dry-matter varies inversely with the size of the root, i.e., the smaller the root the higher, usually, is its percentage dry-matter.

(c) The growing season comprises a period (the length of which varies with different varieties) during which the dry-matter content, as well as the total fresh weight, steadily rises to a maximum. Thereafter, although the fresh weight may continue to increase by the addition of water, there is no further rise in real food value, but usually a definite decrease in dry-matter due to the fact that food production by the leaves does not compensate for the loss due to respiration and other vital processes.

(d) The optimum time for lifting the crop is at the time of maximum dry-matter content, i.e. when the roots are ' mature '. Lifting earlier or later involves a wasteage of solid food and unnecessary carting of water. The three varieties subjected to frequent analyses showed definite differences in this respect corresponding with differences in their rate of maturation. What was of more immediate practical value was the discovery that the same conclusions could be drawn about these three varieties when the data obtained at the three lifting dates in October, December, and February alone were studied.

(e) Using this last fact as a basis, all the twelve varieties lifted on these three dates were provisionally grouped into (1) Early-maturing varieties showing a consistent falling off in dry-matter content from the early autumn ; (2) Mid-season varieties exhibiting a stationary or rising dry-matter content and fresh weight until December, followed by a decline ; (3) Late sorts which either continued to show a stationary or rising dry-matter content throughout the winter in the field.

(f) The results obtained from storing roots in clamps for varying lengths of time supported the conclusions drawn from the field analyses. Storage of late varieties merely imposes an artificial ' maturation ' since no further addition of dry-matter is possible ; whilst, if left in the field during the mild winters usually experienced in North Wales, there is often renewed growth of foliage in the beginning of the year, even in cases when foliage has been previously destroyed by mildew. In the case of early-maturing varieties, the loss of weight in storage appears to be accelerated as a result of autolysis and the action of putrificative organisms. Having regard to these facts, observations on the effects of clamping were discontinued after the first two years.

(2) Comparison of Varieties tested during the period 1933 to 1940.

(a) During the first two years twelve varieties of swedes and two yellow turnips were under trial. The almost complete destruction of the turnips, however, by the root rotting organism (*Bacillus caratovorus* L. R. Jones) in both years, confirmed all previous experience that yellow turnips are unsuitable root crops for the Bangor district and they were thereafter left out of the trials. During the second period of two years (1935-7), five swede varieties were also discarded and replaced by three others. These three varieties were themselves discarded in 1937, leaving seven of the original varieties for which data are available for the whole period of seven years (1933-40).

(b) Fresh weights were obtained by weighing the crop from plots of 1/40 acre for each variety on three dates in October, December and February. At the same time ' cores ' were taken for the estimation of dry-matter.

(c) Disease counts were made on each of the three dates to show the varying incidence of Finger and Toe (*Plasmodiophora brassicae*), Crown Rot (*B. caratovorus*), Dry Rot (*Phoma lingam*), Root Rot (*B. caratovorus*) and Brown Heart (Boron deficiency). During the last two years an estimate was also made of the physiological splitting of the roots to which some varieties are susceptible, and which appears to be solely due to irregularities in the growth of the tissues. Observations on the incidence of mildew (*Erysiphe polygoni* DC.) were made at intervals throughout the season.

(d) The real value of swede varieties depends to a large degree on a correct assessment of the relative importance of (i) fresh weight yielded per acre (see Table I) ; (ii) dry-matter per acre (Table II) ; (iii) the incidence of diseases (Table III) ; and (iv) their keeping power if reserved for late winter feeding. These latter data will be found in Tables IV, V and VI, from which it will also be seen whether a variety can be classed according to the fluctuation in yields as an early, mid-season, or late-maturing sort.

(e) Certain botanical characters are also of some importance to the farmer, such as the tendency of some varieties of swede to produce fanged roots difficult to lift, or thick ' necks ' almost useless for feeding. These features, as well as the ones discussed under (d), are summarised below and are tabulated in Tables VII, VIII and IX.

Garton's White Fleshed Variety: This is a bronze to green-topped tankard variety with a small neck and fanged roots. It is early to mid-season in maturation and, provided the weather is not too severe, it will recover growth after frost. The size of root is definitely above the average, as is also the mean yield per acre both on a fresh weight and dry weight basis ; but is below the average in percentage dry-matter content. It shows no more than average resistance to most diseases except dry-rot, to which it is superior in resistance than are most varieties. In the present (1940) season it has been much less severely attacked by cabbage-white butterfly caterpillars than the adjacent varieties Magnificent and Wilhelmsburger. Has been under trial during the whole period of seven years and can be thoroughly recommended, although unfortunately the supply of seed is often very limited.

Majestic: A purple tankard variety with strong neck and slightly fanged roots. It is an early maturing sort and shows little or no growth after frost. The size of root produced is above the average of all varieties tested and gives an average fresh weight yield per acre; the low percentage dry-matter content of the root, however, results in the dry matter yield per acre being below the average. It is an early variety and shows very little growth after frost. The only maladies to which it exhibits some resistance are physiological splitting of the root and crown rot; a good yield is therefore dependent upon its use on land clean from finger and toe and on the absence of seed-borne diseases such as dry rot. The variety has been under trial for the whole seven years and can only be considered a moderate variety unless earliness is of great importance.

Wilhelmsburger: This is a variety of Danish origin and the trials have included seed direct from that country as well as that from British merchants. Is a green-topped variety with little or no neck and characteristic drooping foliage which, while protecting the bulb from dry rot, renders it more susceptible to crown rot at the heart of the foliage. The bulb is a globe of more than average size and the roots are usually not fanged. There is an average fresh weight yield whilst the high percentage dry matter per root gives more than an average dry weight yield per acre. The variety is the one most resistant to finger and toe. It appears also to show definite resistance to dry rot and to root rot spreading upward from the roots or lower part of the bulb, but is susceptible to crown rot, physiological split and brown heart; during the present (1940) season it suffered worst of three varieties grown from an infestation of cabbage white butterfly caterpillars. The variety is of mid-season to late maturation and grows well after all but the most severe frost. It has been under trial for the whole seven years and can be thoroughly recommended particularly on land contaminated with finger and toe. Compared with Garton's White Fleshed variety, it is superior in resistance to finger and toe and root rot, whilst although below this variety in fresh weight yield, its higher percentage dry matter puts it in the same good class as the White Fleshed variety in yield of dry matter per acre.

Magnificent: Is a purple tankard variety with slightly fanged roots and strong neck. It is an early to mid-season variety and the foliage shows no renewed growth after frost. Magnificent has been under trial for the whole seven years and gives a root of more than average size and fresh weight per acre. The percentage dry matter is low, but, notwithstanding this, the yield of dry matter per acre is above the average of the varieties tested. It can be recommended, but only if clean land is available and the season happens to be unfavourable for the development of diseases, for the only malady to which the variety shows any resistance at all is physiological splitting of the root. During the 1940 epidemic of cabbage white butterfly caterpillars this variety suffered more than Garton's White Fleshed, but less than Wilhelmsburger.

Improved Lord Derby: Bronze to green-topped tankard with very strongly developed neck and fanged roots. The variety has an average sized root, but is below the average in fresh weight yield. However, its high percentage dry matter content enables it to give an average dry weight yield per acre. It is better than many in resistance to mildew, but shows only average reactions to finger and toe and root rot, and is definitely susceptible to the other diseases recorded. Has been tested throughout the seven years and is regarded as only of moderate value. It is a mid-season variety and continues to grow after frost.

Magnum Bonum: Dark purple globe-tankard variety with well developed neck and fanged roots. It is below the average in size of root attained, and in fresh weight yield per acre. Also, despite its high percentage dry matter content the yield of dry matter per acre is less than the average of the varieties tested. Has been under trial for the whole seven years and is early in maturation with no signs of growth following frost. It shows only moderate resistance to finger and toe, crown rot and root rot, but is susceptible to all other diseases and particularly so to mildew. Owing to its low yields and susceptibility to diseases this variety is not recommended.

Superlative: This is a purple tankard variety with upright foliage, no neck and only slightly fanged roots. It has been under trial for the whole seven years and has consistently given less than the average in size of root, fresh weight and dry weight per acre, and also in percentage dry matter. For some reason at present obscure, it suffers much more from the depredations of rabbits than any other variety, except Studsgaard Bangholm, which has been under trial. These pests have been abundant in most years and, without doubt, have been responsible for a considerable reduction in the fresh weight yield per acre. Superlative has a marked resistance to brown heart and is also more than ordinarily resistant to mildew and physiological splitting of the root. Average resistance is shown to other diseases except dry rot, to which it is definitely susceptible. It matures early and shows no renewed growth after frost. For these reasons, as well as its susceptibility to dry rot and loss due to rabbits, it should be lifted and used early. The variety has been tested for seven years and its resistance to brown heart and other diseases make it worth the consideration of the farmer.

Conqueror: Is a green-topped globe-tankard variety, with a strong neck and fanged roots. It produces only a moderately sized root and fresh weight yield per acre, but its high percentage dry-matter content places it above the average in dry matter yield per acre. It appears to be a mid-season variety and gives some indication of renewed growth after slight frosty periods. Shows only moderate resistance to diseases and is definitely susceptible to finger and toe and to brown heart. The variety has been under trial for two years and is useful on land free from finger and toe.

Up to Date: This is a purple-bronze globe variety, with a strong neck and slightly fanged roots. It gives only an average size of root, and is only moderate in fresh weight yield and dry weight yield per acre as well as in percentage dry matter content of the individual root. However, it is distinctly resistant to root rot and shows some resistance to crown rot and to physiological splitting; to all other diseases it appears to be quite susceptible. It has been tested for two years and matured as an early to mid-season variety. Its usefulness depends upon the absence of disease and particularly of dry rot.

Purdy's: This is a dark purple globe-tankard variety; it has a very strong neck, but the roots are only slightly fanged. The variety is below the average in size of root and fresh weight yield per acre and, despite its average percentage dry-matter content, the yield of dry matter per acre is below the average of the varieties tested. It showed some resistance to finger and toe, but was susceptible to all other diseases. The variety was tested for two seasons and matured as a mid-season sort. Owing to its low yield and low power of disease resistance it is not recommended.

Tipperary: A purple tankard variety with little or no neck. It gave above the average size of root, fresh weight and dry matter per acre, but the individual root showed only average percentage dry-matter content. It is definitely resistant to crown rot and moderately resistant to all other diseases except root rot, to which it is susceptible. The variety proved to mature as a mid-season sort in the one year in which the dry matter was estimated and, since the winter was particularly mild, this classification is given with some reserve; a similar condition attaches, for the same reason, to the remaining three varieties described below. Unfortunately, also, very little dry rot developed in any variety during the two seasons in which Tipperary was tested, so that its reaction to this disease is unknown.

Caledonian: A bronze to green globe-tankard variety with a moderate sized neck. The size of the individual root and the percentage dry matter content are about the average of the varieties tested; the high fresh weight yield, however, results in a correspondingly high yield of dry matter per acre. The variety shows no particular resistance to diseases and is definitely susceptible to finger and toe and to crown rot. It has been tested for two years and proved to be mid-season to late in maturation (but see under Tipperary), and showed some slight growth after frost.

Model: This is a bronze globe variety with little or no neck. It was tested for two years, but with the reservations made under Tipperary, the conclusion was reached that the variety is not to be recommended. It matured as an early sort, but was below the average from every point of view both as regards yield and disease resistance; the variety did, however, show some resistance to brown heart.

Studsgaard Bangholm: This Danish variety is a dark purple tankard with a well developed neck. It is definitely below the average in size of root and fresh weight yield per acre whilst, despite the high percentage of dry matter of the individual root, the yield of dry matter per acre remains below the average. The variety was produced by selection from the old Danish variety Bangholm and shows a marked resistance to finger and toe comparable to the variety Wilhelmsburger. It is also definitely resistant to root rot, shows only moderate resistance to crown root and brown heart, and was susceptible to mildew during the year 1934-5, although in previous years there was evidence of definite resistance to this disease. It matured as a mid-season to late variety (but see under Tipperary); it is definitely outclassed in crop production, and at least equalled in resistance to finger and toe, by the more recently introduced Wilhelmsburger variety.

Kinaldie: Is a green globe-tankard variety with strong neck. During the two years of its trial (see under Tipperary) it had nothing to recommend it except some indication of resistance to mildew, but this was counterbalanced by its susceptibility to crown rot. It matured as a mid-season to late variety and showed some growth after frost.

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References.

1. WHITEHEAD, T. The Value of Field Trials with Swedes. *The Welsh Journ. of Agric.* IX. 1933.
2. WHITEHEAD, T. The Effects of Varying the Distance to which Swedes are Singled. *The Welsh Journ. of Agric.* XI. 1935.

TABLE I.

Swede Variety Trials at Aber. Table showing average yield of Fresh Weight per acre. In Tons.

Variety	*2 Seasons 1933-35*	*2 Seasons 1935-37*	*6 Seasons 1934-40*
Garton's White-fleshed ..	20.10	32.15	27.55
Majestic	20.05	24.75	22.45
Wilhelmsburger	19.25	26.70	23.60
Magnificent	17.85	28.10	24.35
Lord Derby	17.55	26.90	21.80
Magnum Bonum	17.55	22.80	20.00
Superlative	16.55	23.05	20.65
Conqueror		26.00	
Up-to-date		25.70	
Purdy's		24.75	
Tipperary	18.40		
Caledonian	18.50		
Model	16.15		
Studsgaard*	12.45		
Kinaldie	12.05		

1 Season only.

TABLE II.

Swede Variety Trials at Aber. Table showing average yield of Dry-matter per acre, in Cwt.

Variety.	*1 Season 1934-35*	*2 Seasons 1935-37*	*6 Seasons 1934-40*
Garton's White fleshed ..	30.25	45.50	39.25
Majestic	27.75	36.00	33.00
Wilhelmsburger	29.25	43.00	38.50
Magnificent	27.25	39.75	35.25
Lord Derby	25.00	41.50	34.00
Magnum Bonum	26.50	34.50	30.74
Superlative	24.00	33.75	30.50
Conqueror		41.50	
Up-to-Date		39.25	
Purdy's		37.50	
Tipperary	27.75		
Caledonian	27.50		
Model	22.50		
Studsgaard	22.00		
Kinaldie	16.00		

TABLE III.

Swede Variety Trials, Aber, 1933-40.

Average Percentage Disease in Field.

Variety	*Period*	*Finger and Toe* *1*	*Crown-Rot* *2*	*Dry-Rot* *3*	*Brown-Heart* *4*	*Root-Rot* *5*	*Physiological Split* *6***
Garton's White Fleshed.	A	6.0	15.5	0.0	28.5	0.0	
	B	15.1	0.0	6.0	15.2	1.4	
	C	11.1	4.7	2.3	28.3	2.1	13.3
Majestic.	A	9.0	7.0	0.5	13.5	2.0	
	B	21.7	0.9	38.6	21.9	3.7	
	C	14.2	3.2	12.2	28.9	3.7	6.6
Wilhelmsburger.	A	2.0	15.5	0.0	32.5	0.0	
	B	4.0	4.8	10.3	26.8	0.8	
	C	2.8	6.7	3.3	31.3	1.1	20.7
Magnificent.	A	18.5	10.5	0.0	29.5	2.5	
	B	14.5	0.3	28.0	17.1	4.8	
	C	15.5	3.6	12.1	30.3	4.8	9.6
Lord Derby	A	7.5	17.5	0.0	21.0	0.0	
	B	12.0	0.8	25.1	25.4	0.8	
	C	12.4	9.1	11.4	30.9	2.2	23.0
Magnum Bonum.	A	7.0	15.0	0.0	26.0	1.5	
	B	12.8	1.7	22.0	27.1	1.1	
	C	9.4	6.0	13.3	31.4	2.3	21.3
Superlative.	A	7.5	15.5	0.0	17.0	0.5	
	B	8.0	0.0	33.4	9.7	1.1	
	C	9.9	4.6	13.6	17.1	2.3	5.3
Conqueror.	B	20.8	2.0	22.0	32.8	0.8	
Up-to-Date.	B	18.9	1.4	30.9	26.0	0.3	
Purdy's.	B	7.1	1.1	32.3	27.7	1.4	*17.5
Tipperary.	A	10.5	12.5	0.0	23.5	2.0	
Caledonian.	A	14.0	21.0	0.5	23.0	0.5	
Model.	A	19.5	24.0	0.0	17.0	0.5	
Studsgaard*.	A	1.3	14.7	0.0	18.7	0.0	
Kinaldie.	A	3.0	33.0	0.0	9.5	0.0	

A = 2 Seasons 1933-5. * = 1 Season only.
B = 2 „ 1935-37. ** = 2 „ „ (1938-40).
C = 7 „ 1933-40.

N.B.—Very little Dry-Rot occurred during 1933-35. Purdy's was the only variety to show Physiological Split prior to 1938.

TABLE IV.

Swede Variety Trial, Aber., 1933-35 (2 Seasons).

Comparison of 2nd and 3rd Liftings with the 1st lifting, the latter = 100.

Variety		*Fresh Weight*				*Dry-Matter*†			
No.	*Name*	*1st*	*2nd*	*3rd*	*Mean*	*1st*	*2nd*	*3rd*	*Mean*
1.	Garton's White Fleshed ..	100	104.5	79.3	94.4	100	86.2	77.5	87.7
2.	Majestic ..	100	96.7	69.8	88.9	100	86.7	74.9	87.3
3.	Wilhelmsburger ..	100	109.5	89.1	99.5	100	183.4	134.5	139.3
4.	Magnificent ..	100	96.6	81.0	92.7	100	126.3	88.5	104.9
5.	Lord Derby ..	100	102.8	95.7	99.4	100	119.1	139.3	119.1
6.	Magnum Bonum	100	96.2	69.4	88.6	100	80.6	74.2	85.5
8.	Superlative ..	100	100.8	71.9	90.9	100	118.1	84.4	101.3
11.	Tipperary ..	100	102.8	77.6	93.4	100	102.6	82.0	94.9
12.	Caledonian ..	100	104.4	85.7	96.7	100	103.7	101.8	101.8
13.	Model ..	100	92.3	74.4	89.0	100	78.8	78.8	85.0
14.	Studsgaard†	100	87.5	87.3	91.5	*Not taken	—	—	—
15.	Kinaldie ..	100	109.0	85.4	98.1	100	115.8	113.8	110.3

† = 1 Season only.
*1st Lifting not taken.

TABLE V.

Swede Variety Trial, Aber, 1935-37. (2 Seasons.)

Comparison of 2nd and 3rd Liftings with the 1st Lifting, the latter = 100.

Variety		*Fresh Weight*				*Dry-Matter*			
No.	*Name*	*1st*	*2nd*	*3rd*	*Mean*	*1st*	*2nd*	*3rd*	*Mean*
1.	Garton's White Fleshed ..	100	106.3	97.6	101.3	100	105.0	95.0	100.0
2.	Majestic ..	100	97.6	97.2	98.2	100	93.5	96.0	96.6
3.	Wilhelmsburger ..	100	101.2	111.7	104.3	100	100.0	106.5	101.8
4.	Magnificent ..	100	92.1	90.9	94.3	100	86.2	87.7	91.4
5.	Lord Derby ..	100	93.6	101.8	98.5	100	85.4	94.4	93.3
6.	Magnum Bonum	100	97.2	79.0	92.1	100	91.6	75.5	89.0
7.	Conqueror ..	100	101.8	104.7	102.2	100	95.3	94.7	97.0
8.	Superlative ..	100	94.6	79.5	91.4	100	84.3	71.1	85.0
9.	Up-to-Date	100	98.3	93.7	97.3	100	91.2	85.8	92.3
10.	Purdy's ..	100	106.4	101.9	120.7	100	98.7	98.7	99.3

TABLE VI.

Swede Variety Trial, Aber, 1934-1940.

Comparison of 2nd and 3rd Liftings with the 1st Lifting, the latter = 100.

Variety		*Fresh Weight*				*Dry-Matter*			
No.	*Name*	*1st*	*2nd*	*3rd*	*Mean*	*1st*	*2nd*	*3rd*	*Mean*
1.	Garton's White Fleshed ..	100	99.0	90.0	96.3	100	98.7	87.8	95.7
2.	Majestic ..	100	100.9	91.0	97.6	100	97.8	87.0	95.0
3.	Wilhelmsburger	100	100.0	99.6	99.8	100	108.0	101.3	103.3
4.	Magnificent ..	100	95.9	85.0	93.8	100	96.7	84.1	93.4
5.	Lord Derby ..	100	94.1	90.0	94.6	100	91.0	89.0	93.7
6.	Magnum Bonum	100	91.2	73.5	88.3	100	87.3	71.8	86.6
8.	Superlative ..	100	95.7	71.1	89.0	100	90.2	66.5	85.3

TABLE VII.

Summary of Swede Variety Trials at Aber. 1st Period, i.e., two Seasons, 1933-4 and 1934-5.

Variety	Colour	Shape	Size of Root	Fresh Weight at Three Liftings				Dry Matter*					Mature	Disease Resistance					
				1	2	3	Mean	Per cent	Weight per Acre, Three Liftings. 1	2	3	Mean	***	Finger and Toe	Crown Rot	Dry Rot**	Brown Heart*	Root Rot	Mildew****
Garton's White Fleshed ..	Bronze to Green.	Tankard Sm. neck; Fanged.	++	+	+	+	+	—	+	+	+	+	Early.	+	A.		—	+	Very Slight to Bad.
Majestic	Purple.	Tankard S. neck, Sl. Fanged.	+	+	+	+	+	—	+	A.	—	+	Early.	A.	+		+	A.	Slight.
Wilhelmsburger	Green.	Globe, no neck øø nor fangs.	+	+	+	+	+	+	—	—	+	+	Mid-Season.	+	A.		—	+	Slight to severe.
Magnificent	Purple.	Tankard S. Neck, Sl. Fang.	+	+	A.	+	+	A.	A.	+	—	+	Mid-Season.	—	+		—	—	V. Slight to Slight.
Lord Derby	Bronze to Green.	Tankard V.S. Neck, Fanged.	A.	—	A.	+	A.	A.	—	—	+	A.	Mid. to Late.	A.	A.		A.	+	Slight.
Magnum Bonum ..	Dark Purple.	Globe to Tankard, S. Neck and Fanged.	—	+	+	—	A.	+	+	—	—	A.	Early.	A.	A.		—	A.	Bad to very bad.
Superlative	Purple.	Tankard No Neck, øø Sl. Fang.	—	—	A.	—	—	A.	—	+	—	—	Mid-Season.	A.	A.		+	A.	Very slight to slight.
Tipperary	Purple.	Tankard Sm. Neck.	+	+	+	+	+	A.	+	+	—	+	Mid-Season.	A.	+		A.	—	V. Slight to very bad.
Caledonian	Bronze to Green.	Globe-Tankard, Mod. Neck.	A.	+	+	+	+	A.	+	A.	+	+	Mid. to Late.	—	—		A.	A.	Slight to bad.
Model	Bronze.	Globe, Sm. Neck.	—	—	—	—	—	—	A.	—	—	—	Early.	—	—		+	A.	Slight to bad.
Studsgaard*	Dark Purple.	Tankard S. Neck.	—	—	—	—	—	—	O.	—	—	—	Mid. to Late.	+	A.		A.	+	Bad to very bad.
Kinaldie	Green.	Globe-Tankard S. Neck.	—	—	—	—	—	—	—	—	—	—	Mid. to Late.	+	—		+	+	Clean to sight.

Notes.—* = one season only. ** = Insufficient disease to justify comparisons. *** = based on dry-matter. **** = none noted in 1933-4. ø = drooping foliage. øø = upright foliage. S. = strong. Sm. = small Sl. = slight.
+ = above average. A. = average. — = below average. O. = not taken.

TABLE VIII.

Summary of Swede Trials at Aber. Second Period, i.e., two Seasons, 1935-6 and 1936-7.

Variety	Colour	Shape	Size of Root	Fresh Weight at Three Liftings.				Dry-matter					Mature	Disease Resistance					
				1	2	3	Mean	Per cent	Weight per Acre, Three Liftings 1	2	3	Mean		Finger and Toe	Crown Rot	Dry Rot	Brown Heart	Root Rot	Mildew
Garton's White Fleshed ..	Bronze to Green.	Tankard Sm. Neck, Fanged.	++	+	+	+	+	—	+	+	+	+	Early to Mid.	A.	+	+	+	A.	Slight to Moderate.
Majestic	Purple.	Tankard S. Neck, Fanged.	+	—	—	—	—	—	—	—	—	—	Early.	—	A.	—	A.	—	Slight to very bad.
Wilhelmsburger	Green.	Globe, No Neck ø	+	—	A.	+	A.	+	+	+	+	+	Late.	+	—	+	—	A.	Very Slight to moderate.
Magnificent	Purple.	Tankard S. Neck, Sl. Fang.	+	+	+	+	+	—	+	—	A.	A.	Early	A.	+	A.	A.	—	Very Slight to very bad.
Lord Derby	Bronze to Green.	Tankard V. S. Neck, Fanged.	A.	A.	A.	+	A.	+	+	A.	+	A.	Mid.	A.	A.	A.	—	A.	Very Slight to moderate.
[illegible]gnum Bonum	Dark Purple.	Gl.—Tankard V.S. Neck, Fanged.	—	—	—	—	—	A.	—	—	—	—	Early.	A.	A.	A.	—	A.	Slight to very bad.
[illegible]nqueror	Green.	Gl.—Tankard V.S. Neck, Fanged.	A.	—	A.	+	A.	—	—	+	+	+	Mid.	—	A.	A.	—	A.	Very Slight to moderate.
[illegible]uperlative	Purple.	Tankard No Neck, øø Sl. Fanged.	—	—	—	—	—	—	—	—	—	—	Early	+	+	+	+	A.	Very Slight to moderate.
Up to Date	Purple to Bronze.	Globe, V.S. Neck, Sl. Fanged.	A.	A.	A.	A.	A.	A.	+	A.	—	A.	Early to Mid.	—	A.	—	—	+	Very Slight to bad.
Purdy's	Dark Purple.	Globe—Tankard V.S. Neck, Sl. Fanged.	—	—	—	—	—	A.	—	—	A.	—	Mid.	+	A.	—	—	A.	Moderate to bad.

Notes: Purdy's also had 17.5 per cent of roots showing physiological splitting, mostly bad, in 1935-6.
See also Notes under TABLE VII.

TABLE IX.

Summary of Swede Trials at Aber. Third Period, i.e. Seven Seasons, 1933-40.

Variety	Colour	Shape	Size of Root	Fresh Weight at Three Liftings.				Dry-Matter.					Mature	Disease Resistance.						
				1	2	3	Mean	Per cent	Weight per Acre. Three Liftings 1	2	3	Mean	***	Finger and Toe	Crown Rot	Dry Rot	Brown Heart	Root Rot	Phys. Split	Mildew
Garton's White Fleshed	Bronze to Green.	Tankard Sm. Neck, Fanged.	++	—	+	+	—	—	+	+	+	+	Early to Mid	A	A	++	A	A	A	A
Majestic	Purple.	Tankard S. Neck, Sl. Fang.	+	—	A	A	A	—	—	—	A	—	Early to Mid.	—	+	—	A	—	+	A
Wilhelmsburger	Green.	Globe, No Neck, No Fang ø	+	A	A	+	A	+	A	+	+	+	Mid to Late	++	—	++	—	+	—	A
Magnificent	Purple.	Tankard S. Neck, Sl. Fang.	+	+	+	+	—	—	+	+	A	+	Early to Mid	—	A	—	—	—	+	A
Lord Derby	Bronze to Green.	Tankard V.S. Neck, Fanged.	A.	—	—	A	—	—	A	—	—	A	Mid.	A	—	—	—	A	—	+
Magnum Bonum	Dark Purple.	Globe—Tankard S. Neck, Fanged.	—	—	—	—	—	—	—	—	—	—	Early	A	A	—	—	A	—	Very Suscept
Superlative	Purple	Tankard No Neck, øøSl. Fang.	—	—	—	—	—	—	—	—	—	—	Early	A	A	—	++	A	+	+

Much loss of yield in Superlative in some years was due to Rabbit damage.
See also Notes under TABLE VII.

GRAZING TRIALS ON OLD AND YOUNG PASTURES AT THE COLLEGE FARM, ABER.

1930-39.

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Introduction.

Grazing trials have been carried out at the College Farm, Aber, for 10 seasons, from 1930-39, in order to find the effects on the live weight increase from a pasture, of including wild white clover when seeding down, and in order to compare the young pasture with old permanent grassland. The stock grazing the pastures was kept under observation, and weighed at intervals during the grazing season. Both the old and the new pastures are about 50 feet above sea level, and are separated only by the width of a field.

The temporary pasture, an 8-acre field, was seeded down in 1927 with the following mixture per acre :—

	lb.
Italian ryegrass	4
Perennial ryegrass	12
Wild perennial ryegrass	8
Cocksfoot	5
Timothy	6
Rough stalked meadow grass	1
Vale of clwyd red clover	5

One half of the field received, in addition, wild white clover at the rate of 1 lb. per acre ; the two portions of the temporary pasture will be referred to as the Wild White, and the No Wild White sections. The temporary pasture was mown for hay in 1928 and 1929, and received a light dressing of farmyard manure between the two hay crops ; no further manurial dressings have been applied.

The permanent grass has been down for at least 70 years, and is considered locally to be a fairly good fattening pasture. Botanical analyses carried out in 1932 showed that a little over 40 per cent of the sward consisted of bent grass and Yorkshire fog. The old pasture received no manure in the course of the trial except for the dressing of mineral manures applied to one half of its area, and discussed later.

The experimental period has, each season, extended from early in May until late in October. Yearling cattle have grazed the fields each year throughout this period, and Welsh Mountain ewes, each with one lamb by a ram of the same breed, have been left on the pastures until the lambs have been ready for the butcher, generally early in July. After this, the plots have been generally left free of sheep for about a fortnight, after which they were stocked with Welsh wether lambs, brought down for the purpose from the mountain.

An attempt has been made at stocking the pasture according to growth, in order to avoid over or under grazing ; this is an essential condition of experiments in which the productivities of pastures are measured in terms of live weight increase.

The data collected in the course of these trials have provided useful information on many aspects relating to the productivities of pastures, both temporary and permanent. Thus, not only have comparisons been made between a temporary and a permanent sward, and between the wild white and no wild white portions of the temporary grass, but such data have been correlated with the botanical composition of the sward. In addition, information has been collected on the extent to which live weight gains per acre are influenced by the summer rainfall. In the early stages of the trial, a feature of unusual interest was observed, namely, the failure of the old pasture, in some years, to maintain lambs in a thriving condition after the middle of August, in spite of sufficient grass. The investigation of this became the main objective of the experiment, and the extension of the trial over a period of 10 years was due to the difficulty of solving this problem.

The information which has been collected will be discussed under two main heads, (a) factors affecting the amount of live weight gain from a given area of grassland, and (b) the failure of lambs to fatten on the old grass in late summer and early autumn. Both aspects have been discussed in previous papers (1), (2), covering the first five years of the experiment.

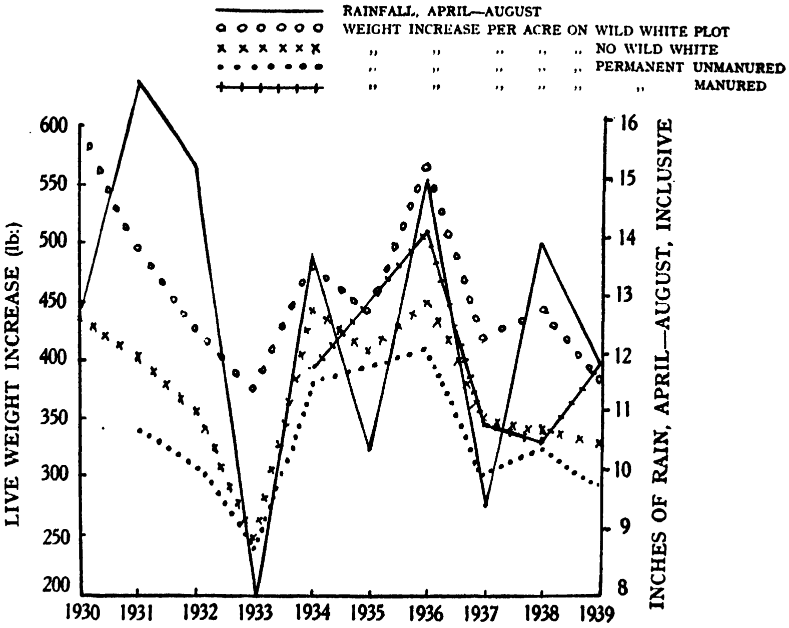
Factors affecting Productivity, as measured by Live Weight Gain.

1. *Seasonal differences in productivity. Effect of rainfall.*

The determination of the live weight increase each season for 10 years has given an opportunity of noting the extent of seasonal fluctuations in the live weight gains, and the influence of rainfall on the productivity of the swards. The influence of weather on the yield of grass is well known to the grazier, and it over-rides the effects of all other factors, such as manuring. This is also clear from experimental data of the yields of grass. At Cambridge for example, Woodman (3) found that the yield of dry matter from the monthly cuts was 2114 lb. in the dry summer of 1929, against 4029 in the favourable summer of 1930. How much more potent is the effect of weather on yield than that of management may be gathered from the statement that, in the wet season of 1930, the yield at Cambridge was 70 per cent more than in 1929, while the greatest difference due to manuring in those years amounted to only 22 per cent. Garner, (4) and Greenhill (5) also supply data showing the important effect of rainfall and water supply on the yield of grass.

FIGURE 1.

Summer Rainfall and Live Weight Increases.



This experiment supplies data on increases in the live weight of stock grazing the various swards from May to October each season, and not on the direct weight of grass produced. In table 1 are shown the live weight increase per acre from each pasture, each year, from 1930-1939 ; the rainfall figures for the 5 months April—August are also included. It may be mentioned that, in the course of the 10 years, the annual rainfall varied from 27.7 to 48.0 inches. It is realized that temperature is also important in growth, but, since this investigation is not mainly concerned with weather factors, no attempt is made to determine their significance, other than that of rainfall.

The rainfall, and the live weight increases are shown graphically in figure 1. It is obvious that the live weight increase has been higher in wet than in dry summers ; the agreement cannot be ex-

TABLE I.

Live weight increase per acre per season (lb.).

Year	*Rainfall April-August (inches)*	*Temporary pastures*		*Old pastures*	
		Wild White	*No Wild White*	*Not manured*	*Manured*
1930	12.92	594	438	—	—
1931	16.65	496	405	340	—
1932	15.29	430	357	310	—
1933	7.85	378	249	243	—
1934	12.84	483	445	381	396
1935	10.51	447	411	394	453
1936	15.08	564	451	407	512
1937	9.56	423	345	296	346
1938	14.00	446	343	324	334
1939	12.10	390	332	297	401

pected to be as good as if the weight of grass were taken, and not live weight increase. The lowest increases were obtained in 1933, the summer with the least rain. Omitting the permanent manured pasture, which was only six years in the experiment, the highest live weight gains exceeded the lowest by 57, 81, and 67 per cent respectively in the wild white, no wild white and permanent unmanured pastures.

In the second and third years of the experiment the live weight increases were not quite as high as might be expected from the rainfall. Thus, in 1931, the summer rainfall was higher than in any of the 10 years, but the weight increases were not as great as in 1936. The reason for this is probably to be found in the distribution of the rainfall. Thus in 1936, the 15.08 in. of summer rain was fairly well distributed, the important growing months of May, June and July having had 2.48, 4,69 and 4.80 inches respectively. In 1931, on the other hand, there were only 1.93 inches in May, 3.19 in June and 2.21 in July ; over a third of the summer rainfall of 1931 fell in August.

2. *Comparison of a temporary and permanent pasture.*

The live weight increases per acre are shown in Tables 1 and 2, and graphically in figure 1. Table 2 shows the gains from each class of stock. The temporary pasture in which wild white clover was

TABLE II.

College Farm Grazing Trials, 1930-39. Gain per acre.

Plot and Stock	*1930*	*1931*	*1932*	*1933*	*1934*	*1935*	*1936*	*1937*	*1938*	*1939*
Wild white										
Ewes	91.4 lb.	60.75 lb.	75.5 lb.	68.7 lb.	73.7 lb.	40.6 lb.	48.00 lb.	42.12 lb.	51.75 lb.	33.75 lb.
Lambs	173.0 ,,	142.50 ,,	165.7 ,,	138.1 ,,	134.9 ,,	139.9 ,,	135.75 ,,	129.00 ,,	110.50 ,,	126.25 ,,
Wether lambs	39.4 ,,	76.00 ,,	76.5 ,,	8.2 ,,	62.2 ,,	91.1 ,,	83.38 ,,	52.13 ,,	77.75 ,,	55.10 ,,
Total sheep	303.8 ,,	279.25 ,,	317.7 ,,	215.0 ,,	270.8 ,,	271.6 ,,	267.13 ,,	223.25 ,,	240.00 ,,	215.10 ,,
Cattle	290.0 ,,	217.00 ,,	112.0 ,,	163.0 ,,	212.0 ,,	175.0 ,,	297.50 ,,	199.50 ,,	206.50 ,,	175.0 ,,
TOTAL	593.8 lb.	496.25 lb.	429.7 lb.	378.0 lb.	482.8 lb.	447.6 lb.	563.63 lb.	422.75 lb.	446.50 lb.	390.10 lb.
No wild white										
Ewes	57.5 lb.	48.45 lb.	72.0 lb.	51.9 lb.	63.0 lb.	44.5 lb.	37.75 lb.	46.88 lb.	42.00 lb.	34.00 lb.
Lambs	128.6 ,,	107.63 ,,	132.5 ,,	114.0 ,,	109.2 ,,	106.5 ,,	115.25 ,,	111.00 ,,	91.00 ,,	103.00 ,,
Wether lambs	18.4 ,,	56.37 ,,	64.7 ,,	15.0 ,,	44.7 ,,	76.0 ,,	63.13 ,,	143.50 ,,	60.75 ,,	39.75 ,,
Total sheep	204.5 ,,	212.45 ,,	269.2 ,,	180.9 ,,	216.9 ,,	227.0 ,,	216.13 ,,	201.75 ,,	193.75 ,,	176.75 ,,
Cattle	233.0 ,,	192.50 ,,	88.0 ,,	68.0 ,,	228.0 ,,	184.0 ,,	234.50 ,,	43.50 ,,	149.00 ,,	155.75 ,,
TOTAL	437.5 lb.	404.95 lb.	357.2 lb.	248.9 lb.	444.9 lb.	411.0 lb.	450.63 lb.	345.25 lb.	342.75 lb.	332.50 lb.
Permanent manured										
Ewes					58.0 lb.	37.3 lb.	47.17 lb.	38.16 lb.	34.00 lb.	43.33 lb.
Lambs					98.0 ,,	129.0 ,,	127.00 ,,	122.50 ,,	100.33 ,,	122.0 ,,
Wether lambs					44.0 ,,	65.3 ,,	87.83 ,,	31.17 ,,	75.66 ,,	28.0 ,,
Total sheep					200.0 ,,	231.6 ,,	262.00 ,,	191.83 ,,	209.99 ,,	193.33 ,,
Cattle					196.0 ,,	221.7 ,,	249.67 ,,	154.00 ,,	123.70 ,,	207.06 ,,
TOTAL					396.0 lb.	453.3 lb.	511.67 lb.	345.83 lb.	333.69 lb.	400.39 lb.
Permanent not manured										
Ewes		23.70 lb.	68.8 lb.	52.0 lb.	56.0 lb.	47.0 lb.	30.00 lb.	26.50 lb.	40.00 lb.	39.33 lb.
Lambs		102.50 ,,	131.8 ,,	107.0 ,,	95.0 ,,	106.5 ,,	108.33 ,,	106.50 ,,	84.30 ,,	99.00 ,,
Wether lambs		41.80 ,,	38.0 ,,	—	39.0 ,,	63.0 ,,	70.83 ,,	6.83 ,,	50.00 ,,	23.33 ,,
Total sheep		168.00 ,,	238.6 ,,	159.0 ,,	190.0 ,,	216.5 ,,	209.16 ,,	139.83 ,,	174.30 ,,	161.66 ,,
Cattle		172.00 ,,	71.0 ,,	84.0 ,,	191.0 ,,	177.3 ,,	198.33 ,,	156.33 ,,	149.30 ,,	135.33 ,,
TOTAL		340.00 ,,	309.6 ,,	243.0 ,,	381.0 lb.	393.8 lb.	407.49 lb.	296.16 lb.	323.60 lb.	296.99 lb.

TABLE I.

Live weight increase per acre per season (lb.).

Year	*Rainfall April-*	*Temporary pastures*		*Old pastures*	
		Wild	*No Wild*	*Not*	

and graphically [illegible]
of stock. The temporary pasture in which wild white clover was

included when seeding down, which is the usual kind of pasture at the farm, gave live weight gains varying from 378 lb. to 594 lb. per acre, whereas those in the unmanured old pasture varied from 243 to 407 lb. per acre. If the year 1930 is excluded, when no records are available for the old pasture, the average live weight increases per acre per annum were as follows :—

Comparison of temporary and permanent pasture.

Average live weight gain per acre per annum (lb.). 1931—1939.

Temporary pasture (wild white)	*Permanent pasture (not manured)*	*Excess of live weight gain from temporary pasture, as percentage of that on old pasture*
450.8 lb.	332.4 lb.	35.6

The average live weight gain on the manured old pasture has been omitted from this comparison because records for that field were available for six years only.

Thus, difference between average live weight gain on temporary and old pasture = 118.4 lb.

Standard error* of the difference = ±10.5 lb.

The difference is clearly significant.

It might be expected that the superiority of the temporary grass would decrease with age. The table below shows that such is not the case.

Comparison of old and new pasture in first and second periods of experiment.

Average live weight increase per acre per annum (lb.).

Period	*Temporary pasture*	*Permanent pasture (not manured)*	*Percentage superiority of temporary pasture*
1931-35	446.6	333.5	33.3
1936-39	445.7	331.0	37.6

Thus the superiority of the temporary pasture over the old pasture was maintained throughout the period, and showed no sign of diminishing.

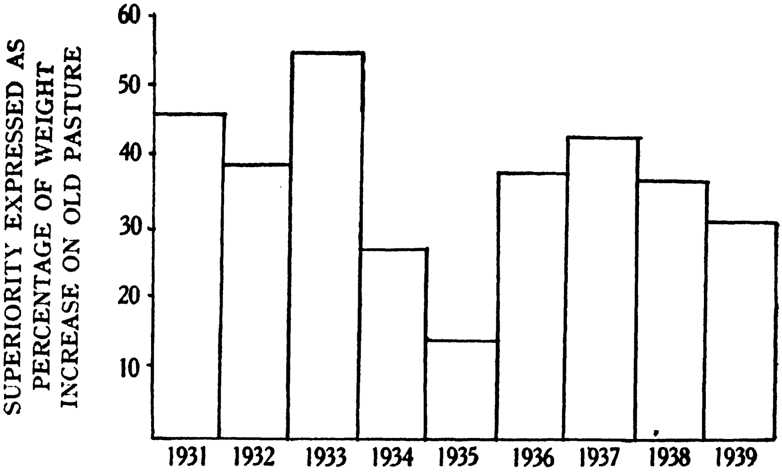
The maintenance of this superiority is illustrated graphically in figure 2.

---

*The Standard Error of the difference has been calculated from the formula $SE_d = \sqrt{SE_1^2 + SE^2_2 - 2\,r\,SE_1, SE_2}$, where r is the correlation coefficient between the live weight gains.

FIGURE 2.

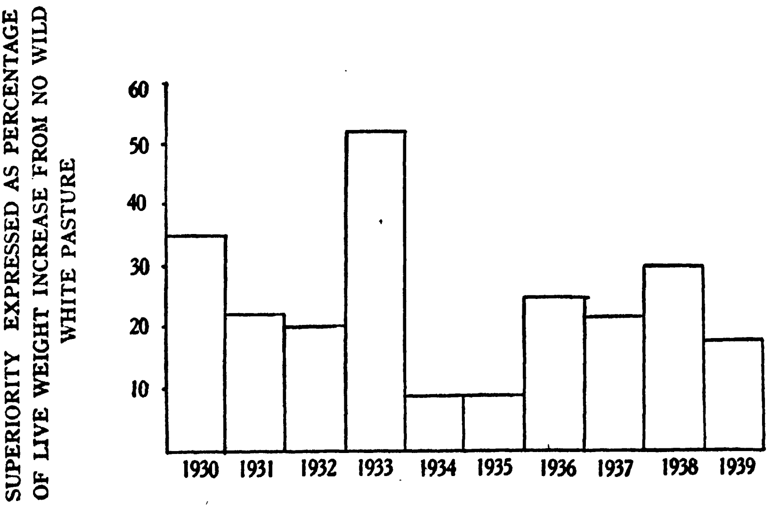
Superiority of Temporary over Permanent Pasture.



It may, however, be pointed out that, in 1930, the first grazing year of the temporary pasture, the live weight on the wild white portion was higher than it has been in any subsequent year, and that the gain on the no wild white plot in that year had only been surpassed, to a small extent, on two occasions; no records are available as to the gain on the old pasture in 1930.

FIGURE 3.

Superiority of Pasture in which Wild White Clover was included when seeding down.



An examination of the stocking of the plots, and of gains in weight of each individual animal shows that the superiority of the temporary sward is due mainly to its greater stock carrying capacity. It may be noted, however, that, particularly in some years, the wether lambs on the temporary pastures were markedly superior to those on the old pastures; this will be discussed later. Reference to the data obtained from botanical analyses of the swards indicates that the sustained superiority of the temporary pasture is probably due to its having maintained a high proportion of perennial ryegrass and wild white clover, while, in the old pasture, the proportion of these constituents was low; in the permanent sward, bent and Yorkshire fog continued to occupy dominant positions. There is strong reason for concluding that, when a pasture is properly laid down, it will continue to be highly productive for at least 10 or 12 years under conditions of soil and climate similar to those at Aber, provided it is managed in such a way as to maintain a high proportion of perennial ryegrass and wild white clover.

3. *The influence of manuring on the productivity of the old pasture.*

The old pasture was, early in 1934, divided into two portions, one of which was treated with mineral manures and the other was left unmanured; the manures supplied per acre were 1 ton of ground limestone, 5 cwt. of basic (15 per cent P^2O^5), and 3 cwt. of kainit. Though manuring was primarily carried out in order to investigate the failure of the old pasture to maintain lambs in a thriving condition in autumn, it has provided data on the effect of manuring on live weight gain and on the botanical composition of the herbage.

Tables 1 and 2 show the live weight increases per acre each year on both manured and unmanured portions of the old pasture, and, in the table below, are shown the average gain per acre per annum over the 6 years.

Influence of manuring on liveweight gain per acre from an old pasture. Average live weight gain (lb.). per acre per annum, 1934-39.

Permanent pasture.

Not manured	*Manured*	*Percentage increase due to manuring*
349.7	407.0	16.4

Manuring has thus raised the average annual gain per acre of the old grass from 349.7 to 407 lb., i.e., by 57.3 lb., or 16.4 per cent. The Standard Error of the difference, i.e., of the 57.3 lb., is ± 15.32, so that it is clearly significant. While manuring has raised the productivity of the old pasture above that of the temporary sward from which wild white clover was omitted, it has not raised it to the level of that of the temporary sward which was seeded down in the usual way with wild white clover. If the average live weight increase from the unmanured old pasture is put at 100, that from the manured plot is 116, and that from the wild white clover plot 131.

An examination of the figures for the total live weight gains of each class of stock on the manured and unmanured old pastures was made to find whether any particular class of stock responded more than another to the manuring. The results are as follows :—

Responses of stock to manuring of old pasture.

Stock	*Percentage increase in total live weight gain per acre, as a result of manuring*
Ewes	8.0
Lambs	16.5
Wether lambs	31.3
Cattle	14.3
All Stock	16.3

Thus, the contribution made by the wether lambs to the total live weight increase per plot was raised more than that of the other classes of stock as a result of manuring the permanent pasture.

Botanical analyses of the swards showed that the manuring resulted in a marked decrease in the proportion of bent and Yorkshire fog in the old pasture ; this is seen in Table 3. The increase in productivity as a result of manuring must be partly due to the change in botanical composition.

4. *Effect of including wild white clover when seeding down.*

The temporary pastures, sown in 1927, have received similar treatment throughout, the only difference being that, when seeding down, wild white clover was included in one and omitted from the other. It has thus been possible to measure in terms of live weight increase, the effects of including this constituent in the seeds mixture ; in addition, botanical analyses have been made, thus enabling differences in weight increases to be correlated with the botanical nature of the herbage.

The live weight increases per acre, per season, are shown in Tables 1 and 2. The pasture in which wild white clover was included gave live weight gains ranging from 378 to 594 lb. per acre, while that in which no wild white clover was included showed gains ranging from 249 to 451 lb.

The table below summarises the results over the period of 10 years; the average gain per acre per annum is given for all stock and also for each class of stock.

Effect of including wild white clover, 10 years, 1930—1939.

Stock	*Live weight increase per acre per annum*		*Excess of live weight increase on wild white expressed as percentage of that on non-wild white*
	Wild white clover	*No wild white clover*	
Ewes	58.6	49.8	17.7
Lambs	139.1	111.9	24.3
Wether lambs	62.0	48.1	28.8
Total sheep	259.8	209.8	23.9
Cattle	204.7	167.6	22.1
Total, all stock	464.4	377.4	23.0

If the average live weight increase from the no wild white clover plot is put at 100, that from the wild white clover pasture becomes 123, a difference which is clearly significant, i.e., the inclusion of wild white clover in the seeds mixture has resulted, over a period of 10 years, in an average gain of 23 per cent.

The no wild white clover plot, has, throughout the experiment, contained an appreciable amount of indigenous wild white clover, and it might be expected that this would have increased in proportion, and that, ultimately, the live weight gains would have been equal on both plots. An examination of the results indicates, however, that omitting 1930, the first year of the trial, the superiority of the pasture in which wild white clover was included when seeding was maintained throughout the period, and that there was but little tendency for this superiority to diminish at the end of 10 years. Thus, in the four years 1931-34, the wild white plot was, on the average, better than the no wild white plot to the extent of 82 lb. per annum; in the five subsequent years, 1935-39, the average annual difference was 77.5. The maintenance of this superiority is shown graphically in figure 3. That the wild white plot maintained its superiority is also evident from an examination of Figure 1.

Observation of the plots, and the results of the botanical analyses suggest that the maintenance of this superiority is due to the wild white clover that was included in the seeds mixture of one plot having prevented weeds and poor grasses from establishing themselves in the early years; when wild white clover was omitted, the inferior plants obtained an early foothold, and maintained it throughout the ten-year period. The proportion of bent and fog, taken together, are shown in Table III.

Table III.

Percentage of bent and Yorkshire fog in October (1933—1939).

	1933	1934	1935	1936	1937	1938	1939
Permanent pasture :							
Manured	—	27.8*	28.7	30.0	28.4	32.3	37.0
Not manured	38.5*	66.5*	53.4	56.7	59.7	45.2	51.2
Temporary pasture : W. white included	not examined	trace	4.1	3.7	9.5	15.7	14.0
No w. white included	trace	not examined	6.8	18.7	20.5	25.0	25.7

*Bent only.

5. *The production of meat from good grassland.*

The results of these experiments add interesting information on the productivities of good and medium quality grassland, and enable comparisons to be made with pastures in other parts of Great Britain. The wild white clover pasture, which is typical of the College Farm temporary leys, has produced an average of 464 lb. of live weight increase per acre, per season, over the 10-year period 1930-1939; this is equivalent to about 240 lb. of dressed carcase. If an addition of 5 per cent is made, to allow for production in the winter months, the average annual production of dressed meat was about 252 lb. per acre. If a moisture content of 45 per cent is assumed, the annual production has averaged approximately 140 lb. of dry matter in the form of meat.

The high level of productivity of the temporary pasture included in this trial is obvious when compared with some pastures in other parts of the country. Sir Thomas Middleton (6) gives the average annual production of meat from the best fattening pastures as 180-200 lb., from the average permanent pasture of the country, 72 lb., and from poor permanent pastures, 20-30 lb. Data from the Welsh Plant Breeding Station show that 200-300 lb. of meat per acre have been produced from pastures improved by reploughing and reseeding. The production of 240 lb. of meat from the temporary pasture in this experiment is thus equal to that of the best fatting pasture,and to that of pastures improved by reseeding. It is important to realise that live weight gain is dependent not only on the pasture, but also on the kind of stock grazing the pasture, growing animals putting on weight more rapidly than mature animals. Even allowing for the fact that all the stock, except the ewes, used in this trial favoured good weight gains, the high productivities of these temporary leys are worthy of special note.

(*b*) Failure of the old pasture to maintain lambs in a thriving condition in late summer.

1. *Introduction.*

In 1931, when this trial first included a comparison of the temporary and permanent pastures, it was discovered that, after the middle of August, there was a marked difference in the condition of the lambs grazing the two fields. The wether lambs, which had been brought down from the mountain and put on the plots about the end of July, continued to thrive equally well on both pastures until about the middle of August, but, after that date, those on the old grass fell back in condition, while those on the younger pasture continued to fatten. Thus in that year, the lambs on both pastures increased in live weight from an average of 45 lb., to 53 lb., from the middle of July to the middle of August. By the middle of September, the lambs on the temporary grass had gained another 2.5 lb. against only 0.6 lb. by those on the old grass. By the end of the month, the lambs on the former pasture had gained another 0.5 lb., whereas those on the old grass had lost weight. This is illustrated in. Figure 4.

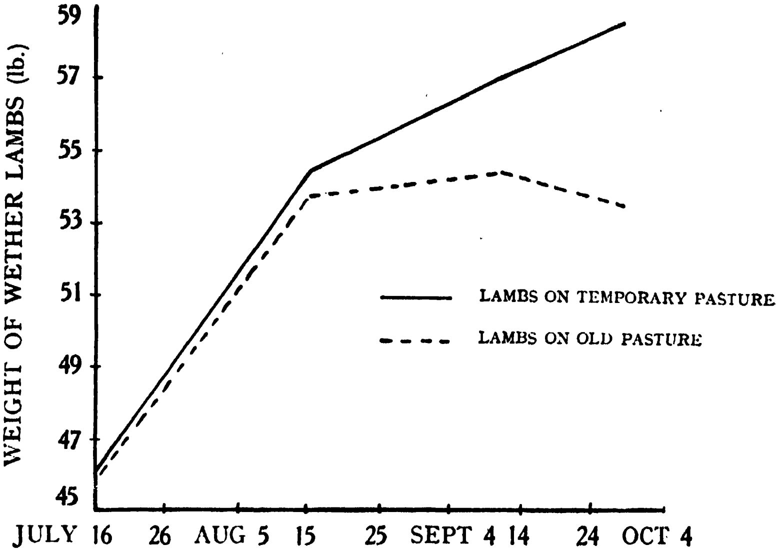
The difference between the two lots of lambs was greater than is indicated by live weight only ; the loss of condition of those on the old pasture was obvious to the eye, and their wool parted on their backs, as is usual with sheep that are in an unthrifty condition.

The failure of the lambs to thrive on the old pasture occurred in spite of a sufficiency of grass, and of the fact that young, growing cattle continued to increase in weight and to keep in good condition.

The sharp difference in the grazing effects of two pastures, on similar soil, and situated only the breadth of a field apart, appeared worthy of further investigation, especially in view of the fact that similar failures of lambs to fatten on apparently good permanent pastures were known in other parts of North Wales. The experi-

FIGURE 4.

Late Summer and Early Autumn effect of old Pasture.



ment was accordingly prolonged for a number of years, in the hope of finding a satisfactory explanation for the defect in the old pasture. As was pointed out in the previous papers, the difference between the two pastures might be due to a difference in the degree of worm infestation, or to a nutritional defect in the old pasture as a result, for instance, of a higher proportion of bent and Yorkshire fog. It was obvious that the problem called for investigation along several specialized lines, and, for this reason, it was tackled in collaboration with the departments of Veterinary Investigation, Agricultural Botany and Agricultural Chemistry; discussions were held at intervals in order to plan out the trial for the year following, and to discuss the data received at the end of each season.

2. *Live weight gains in the critical periods.*

Table III shows the average gain in the live weight of the wether lambs each season and also the gains in the critical period of each season; the critical period extends from the middle of August to the time the wethers were taken off the pasture, about the middle of October.

Early in 1934, in order to find out whether a deficiency of some of the ordinary minerals was at the root of the trouble, half of the old pasture field was dressed with one ton of ground limestone, 5 cwt. of slag, and 3 cwt. of kainit per acre. Table IV includes both the manured and unmanured sections of the old grass.

TABLE IV.

Average Gain per Head in weight (lb.) of Wether Lambs, 1931-1939.

(a) Over Whole Period.

Plot		1931	1932	1933	1934	1935	1936	1937	1938	1939
Temporary.	Wild white	12.6	12.7	2.0	11.7	15.2	16.83	10.43	15.55	11.1
	No wild white	12.5	12.9	3.8	11.7	15.2	15.82	10.97	15.19	10.0
Permanent.	Manured	—	—	—	11.1	10.9	15.20	6.23	15.13	5.6
	No manure	7.7	9.5	— 0.3	9.8	12.6	15.32	1.67	12.50	5.8

(b) Over Critical Period. (Middle of August to middle October.)

Plot		1931	1932	1933	1934	1935	1936	1937	1938	1939
Temporary.	Wild white	3.8	8.2	2.0	5.3	6.6	12.1	5.4	11.3	6.6
	No wild white	4.5	8.0	3.8	4.8	6.1	6.2	5.6	10.8	4.5
Permanent.	Manured	—	—	—	4.7	2.2(S)	10.1	2.4(S)	8.7(S)	1.4(S)
	No manure	—0.2(S)	4.4(S)	—0.3(S)	2.9(S)	3.5(S)	10.4	2.0(S)	7.6(S)	2.5(S)
Difference in mean gain per head, on Wild white and Permanent No Manure		4.0	3.8	2.3	2.4	3.1	1.7	7.2	3.7	4.1
Standard Error of difference		0.65	1.08	0.95	1.13	1.11	1.29	1.17	1.31	1.19

Note.—(S). The difference between this mean weight per lamb, and that on the wild white plot is significant.

It will be observed that :—

(*a*) In the critical period the average live weight gain per lamb on the wild white pasture was significantly higher than that on the permanent unmanured field every year except 1936, and significantly higher than that on the permanent manured pasture every year except 1934 and 1936. In some years, the superiority of the lambs on the temporary pasture was so obvious, that it could be detected without the weighing machine.

(*b*) Although the temporary pasture was 12 years of age in 1939, its superiority in this respect was as clear as at any time in the course of the 10-year period.

(*c*) The application of the mineral manures has not corrected the defect in the old pasture.

3. *Principal facts relating to the defect in the old pasture.*

Before attempting to find an explanation for this late-summer and autumn effect of the old pasture, it may be well to state the principal facts relating to it. These are :—

1. The failure of the lambs to thrive occurs in lambs dropped in April, and brought down from the mountain about the middle of July, when they are weaned and put on the plots; lambs grazing the old pasture from May onwards fatten without difficulty, and are sold in July.
2. The lambs begin to lose condition about the middle of August.
3. The difference between the lambs on the temporary and permanent pastures is very obvious in some years, and scarcely perceptible in others.
4. Yearling cattle continue to thrive on the old pasture while the lambs lose condition.
5. There is no shortage of grass while the lambs lose condition, nor is the grass too long.
6. The application of limestone, slag, and kainit to the old pasture did not remedy the defect.
7. The loss of condition of the lambs in the old grass appears to be deep rooted, because they continued to deteriorate after their subsequent removal to a good young sward.
8. At the conclusion of the period of the trial, when the temporary pasture was 12 years of age, and thus could scarcely be termed young, the difference between the lambs on the pastures was as manifest as at any time.

9. The old pasture had a much higher proportion of poor grass than the temporary.

4. *Discussion of the case for attributing the defect to worms.*

Many old pastures are said to be heavily infested with worm eggs and larvae, through having been stocked with sheep for a number of years. In the early stage of this experiment, it was considered possible that the old pasture, which was over 60 years of age, would carry a much heavier worm infestation than the young pasture, which had been grazed for one full season only prior to the start of the experiment ; it was considered that this might provide an explanation for the defect in the old pasture. This, however, appeared less likely as the temporary sward increased in age. Thus, in 1939, when the temporary grass had been heavily stocked with sheep for 10 seasons, and by which time it had had an opportunity of reaching its maximum worm burden, its superiority was as clear as ever. While admitting, however, that the younger pasture had ample time to reach its maximum worm burden, the possibility must be conceded of the physical condition of the sward on the older pasture being more favourable to the wintering of worm eggs, etc. The sward of the permanent grass contains a high proportion of bent and fog, and is more matted than that of the temporary pasture ; such a matted condition may favour a high worm survival.

In 1933 the faeces of the lambs were examined to make counts of nematode ova. A greater number of worm eggs were found in the faeces of the lambs grazing the old grass. While this was regarded as evidence in support of the parasitic explanation, it was borne in mind that the heavier worm burden of the lambs in the old grass might have arisen from a nutritive defect ; it is known that an inadequate level of nutrition encourages parasitic infestation.

In 1936 all the wether lambs on the pastures were dosed once with a wormicide ; it was intended to find whether the difference in the lambs grazing the old and the new pastures would disappear if all lambs were protected from worms. In that year both lots of lambs thrived equally well. It may be pointed out, however, that 1936 was a particularly favourable growing year, owing to the high spring and summer rainfall. It may also be noted that one dosing for worms would not be expected to keep the lambs free from the middle of July to the middle of October.

In 1939, when a more efficient wormicide had become available, half the lambs on each plot were dosed at intervals of three weeks with copper and nicotene sulphate. Table 5 shows the effect of dosing on the live weights gains of the lambs during the critical period.

TABLE V.

Effect of dosing on live weight gain of lambs, in critical period (August 25 to October 6), 1939.

Plot	*Average live weight gain per lamb (lb.)*		*Difference due to dosing (lb.)*	*Standard Error of Difference*	*Whether difference is significant**
	Dosed	*Not dosed*			
Wild white	7.3	5.8	1.5	1.19	No
No wild white	4.1†	5.5	—1.4	1.20	No
Permanent manured	3.4	1.9†	1.5	1.23	No
Permanent not manured	4.6	0.3	4.3	1.42	Yes
All plots	5.1	2.6	2.5	1.07	Yes

*A difference is regarded as significant if it exceeds twice its Standard Error.

†One lamb discarded owing to maggots, etc.

Dosing gave a statistically significant improvement in the lambs on the old unmanured pasture. In calculating the Standard Error of the gain on the manured pasture, one very badly thriving lamb was discarded. Had this been included, the difference would be significant. While dosing resulted in an improvement in the lambs on the old pastures, it did not quite raise them to the level of those on the better, temporary grass.

The results from dosing in 1936 and in 1939 suggest that parasites are the cause of the trouble on the old grass. In 1939, however, careful examinations of the stomach contents of the lambs by the Veterinary Investigation Officer, a fortnight after the final dosing, did not reveal a difference in the worm burden of the dosed and undosed lots of lambs. It was expected that, since dosing appeared to have been so effective, a much heavier worm count would have been found in the undosed lambs. It should be noted, however, that the examination of the stomach contents was not made until a fortnight after the final dosing; the lambs would have had an opportunity of becoming reinfested in the meantime.

Another point favouring the parasitic explanation is the fact that the loss of condition of the lambs on the old grass cannot be made good at once by removing them to a young pasture of high quality; the difference in the condition of the two lots of lambs tended to widen, rather than to diminish. This would be expected if the lambs on the old grass had become heavily infested with worms, which would continue their harmful effects after the removal of the sheep to good pasture.

Some support for the view that the cause of the trouble is parasitic and not nutritive is found in the results of applying mineral manures to a portion of the old pasture in 1934. An examination of Table 4 shows that manuring the permanent grass with lime, slag, and kainit did not influence this defect in the old pasture; the trouble was acute in 1937 and in 1939. It thus appears as if the trouble is not due to a deficiency of the ordinary minerals to be found in ground limestone, slag, and kainit. Such negative evidence supports the parasitic explanation.

5. *Discussion of the case for attributing the defect to a nutritive cause.*

If the cause of the failure of the old pasture to fatten lambs in late summer and in autumn is nutritional, it may be due to a deficiency of some of the ordinary constituents, such as proteins, or sugars, or it may be due to a lack of some mineral, vitamin, etc.

Analyses carried out in the Agricultural Chemistry Department showed that there was only a small difference between the old and the new pastures as regards the usual chemical constituents. Again, the failure of the application of mineral manures to remedy the defect in the old sward indicated that such defect was not due to the usual elements found in limestone, slag, and kainit. It is possible that the superiority of the temporary pasture in autumn may be due to its herbage having a higher digestibility. While there are no data on this point, it may be added that work on the digestibility of grass indicates that grasses of similar crude protein content have a similar digestibility. This evidence, which is of a negative character, suggests that, should the cause be nutritional, it is due to a lack of some of the more obscure substances, such as the trace elements.

If the cause is nutritional, there is, as was pointed out in the two previous papers on the subject, evidence that it may be related to the higher proportion of bent and Yorkshire fog in the old pasture. Both grasses are deficient in minerals, the former in lime, and the latter in phosphate; even when the sward is treated with mineral manures, such grasses may be unable to supply the grazing animal with an adequate amount of these minerals. The proportion of bent and Yorkshire fog is known to increase in pastures towards autumn, and this corresponds to the period when the lambs lose condition. Thus, as has been pointed out previously, (1) and (2), the proportion of bent in 1934 increased from 24.8 per cent in the spring, to 66.5 per cent in October. The proportion of both these poor grasses was low in the temporary pastures.

While the differences in the proportion of these two inferior grasses is sufficient to account for the superiority of the temporary pastures in late summer and early autumn, they do not provide an explanation of the fact that, in some years, the lambs thrive quite well on the old pasture. Table 3 shows the proportion of bent and Yorkshire fog in the experimental pastures each autumn, and it is clear that the proportions of bent and fog in the old pastures are much higher than in the temporary swards. It is obvious, however, that in so far as the proportions of bent and fog are concerned, there seems no reason why the characteristic defect in the old pasture should not have appeared in 1936.

In order to get further evidence on this point, i.e., the possibility of the defect in the old pasture being due to the high proportions of bent and fog, an examination was made of the gains in weight of the ewes and lambs grazing the plots in the earlier part of the season.

In the last five years, 1935-39, the average annual gain per couple was 16.8 lb. on the wild white plot, and 17.1 on the old, unmanured pasture, in spite of the fact that the proportion of poor grasses averaged 35.3 per cent in the latter, against 8.4 per cent in the former. Thus, in the early part of the season there does not appear to be a relationship between the thriftiness of the couples and the proportion of poor grasses. It may be urged that the amounts of poor grasses are higher later in the season, but that, in the early part of the season, they have not reached a sufficiently high level to be dangerous. Against this, however, it must be pointed out that the level of poor grasses in May on the old unmanured pasture was as high as it was on the manured sward in autumn.

6. *Effect of summer rainfall on defect of old pasture.*

Attention may be called to the influence of summer rainfall on this defect of old pasture. With the exception of 1931, the seasons when the lambs have failed to thrive on the old grass have been dry. These were: 1933, 5, 7, and 9, when the rainfall from April to August was 7.8, 10.5, 9.5 and 12.1 respectively, against 15.3, 13.8, 15.1 and 14.0 in the years when the lambs thrived better on the old pastures. However, the summer rainfall in 1931 was abundant, but the failure of the lambs was as marked as ever. Had this comparison started one year later, and the results for 1931 not been available, the evidence would have seemed sufficiently strong to connect the defect of the old sward with the summer rainfall.

It may be mentioned, in this respect, that soil profiles examined in late July, 1939, showed very distinct differences between the temporary and the permanent pastures. The former, which had the healthy-looking type of sward, in which the soil was visible between the plants, was moist to a depth of 4 to 5 inches. In the latter, in spite of moderate amounts of rain, the soil was bone-dry under the sward. Although the old turf could not be termed badly matted, it appeared as if there was sufficient mat to prevent the soil getting the benefit of the summer showers. This suggests that, in the old grass, there may be a nutritional deficiency arising from the soil being too dry, and perhaps also insufficiently aerated. It may be mentioned, in this respect, that the cases of cobalt deficiencies that have been noted in New Zealand have occurred in districts of low rainfall.

7. *Discussion.*

The experiments and observations have failed to show conclusively that either worms or a nutritional factor are alone responsible for the failure of the lambs to thrive on the old pasture in late summer and early autumn ; there is evidence both for and against both explanations. The results of dosing with a wormicide in 1936 and in 1939 are in favour of the parasitic explanation, but the examination of the stomach contents at the conclusion of the 1939 trial did not reveal much difference between the two lots of lambs in this respect. Again, the fact that the temporary pasture is now 12 years old suggests that it has had ample opportunity of obtaining a maximum infestation with the ordinary sheep stomach worms. Regarding the nutritional theory put forward to explain this difference, the failure of a mineral dressing to remedy the defect in the old pasture indicates that there does not appear to be a deficiency of the minerals usually found in lime, slag, and kainit, unless bent and fog, which constitute nearly half the sward in the old grass, cannot transmit such minerals to the animals. The increase in the proportion of bent and Yorkshire fog towards autumn occurs at about the same time as the loss in the condition of the lambs, and this indicates a nutritional deficiency connected with the presence of too much of these poor grasses. On the other hand, the proportion of such grasses does not make it possible to explain why the loss in condition of the lambs on the old pasture is so pronounced in some years, and not in others.

It is probable that the defect in the old pasture may be due to a combination of two or more factors. Thus, it may be possible that, in some years, the lambs on the old grass are not adequately nourished, and that, although they may have no more worms in the stomach than those on the new pasture, they fall victims to that number of worms. This explanation, however, still makes nutrition the primary cause of the trouble.

It is difficult to determine what elements or constituents may be lacking in the old grass; chemical analyses, and the lack of response to mineral manuring, indicate that the deficiency is not in ordinary constituents, such as proteins, nor in the more common minerals. It is possible that there may be a lack of some trace element in the old grass towards autumn. Old pastures often lose much of their green colour towards autumn, and it is possible that this loss of colour may be accompanied by a decrease in the amounts of some of the elements associated with chlorophyll formation, such as magnesium or cobalt. A healthy, actively growing sward, with a good proportion of perennial ryegrass and wild white clover, maintains a good, green colour throughout the year; a less open sward, such as is found on many old pastures, is not able to continue in such a green condition. It is not unlikely that the easier penetration of the soil of the temporary pasture by summer rain and air may be responsible for its sward being maintained in a more fresh and growing condition.

While this experiment has not enabled us to provide an adequate explanation for the defect in the old pasture, we have the satisfaction of knowing that this trouble can be prevented if a pasture is so managed that the proportions of perennial ryegrass and wild white clover are maintained at a high level. When the pasture cannot be maintained in such a condition by cultivation, grazing, and manuring, it should be ploughed up, and reseeded.

Conclusions.

(1) Grazing trials have been carried out at the College Farm, Aber, for ten years, from 1930-1939. A temporary pasture in which wild white clover has been included when seeding down was compared with one from which this constituent had been omitted, and these were compared with an old pasture.

(2) The live weight increases per acre varied from season to season, and were influenced greatly by summer rainfall. The live weight gain in the most favourable season was as much as 81 per cent higher than in the poorest season, 1933.

(3) The live weight increase per acre was, over a 9-year period, 35.6 per cent higher from the temporary wild white pasture, which was unmanured, than from the permanent unmanured field. This was mainly due to a greater stock carrying capacity.

(4) This superiority of the temporary grass did not appear to be diminishing towards the end of the period.

(5) The inclusion of wild white clover in the seeds mixture resulted, over a period of 10 years, in an average annual increase of

23 per cent in the live weight gain. This was due to a greater stock carrying capacity.

(6) In spite of the presence of an appreciable amount of wild white clover appearing naturally in the plot where it was not sown, the superiority of the pasture in which it was sown showed no signs of diminishing.

(7) Manuring raised the productivity of the old pasture by 16.4 per cent, and this was accompanied by a marked decrease in the proportions of bent and Yorkshire fog.

(8) The most interesting feature of the experiment was the failure of lambs to thrive in some years on the old pasture after about the middle of August. The investigation of this problem ultimately became the main objective, and evidence is discussed both for and against attributing the defect to parasitic or to nutritional causes.

Acknowledgments.

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References.

1. Sheep Sickness of Permanent Pasture. Roberts, E. J. *Journ. of Ministry of Agriculture.* XL. 4. (July, 1933.) 337—343.
2. Comparison of an Old with a Temporary Pasture. Roberts, E. J. *Welsh Journ. of Agriculture.* XI. (1935.) 132-139.
3. Nutritive value of pasture. Woodman, H. E., Norman, D. B., and French, M. H. *Journ. Agric. Science.* (1931.) 21. 267-324.
4. The Grassland of Hertfordshire. Gardener, H. W.
5. Grassland Investigations. Greenhill, A. W. *I.C.I. Report A.R.A.* 411.
6. Food Production in War. Sir Thomas Middleton.

SOIL FERTILITY DATA FOR A FIFTEEN-YEAR MANURIAL EXPERIMENT ON HAY LAND.

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The data here presented were obtained for soils taken from experimental plots on the manuring of meadow land for hay at the University College Farm, Aber. The plots were laid down in 1924 and hay taken from the land annually. The experiment was discontinued after the removal of the 1939 Crop and the plots ploughed up during the autumn of the same year.

The soil may be described as medium loam* derived from Paleozoic grits and shales and overlying red triassic boulder clay. The surface soil appears to be fairly uniform in character passing to the sub-soil at a depth of about 12″. From 12″—18″ only slight traces of the influence of the red boulder clay are to be observed. The drainage is fairly good but the land is somewhat wet during the winter.

The plots were ten in number including two controls. None of the others was duplicated. Before ploughing, samples were taken from each of the plots at the following depths 0—3,″ 3—12″, and 12—18.″ In addition the 3—6″ and 6—9″ layers were sampled from the controls and the slag treated plots.

The manurial treatments with the approximate amount of each fertilizing ingredient applied during the period and the mean hay yields are shown in Table I.

Farmyard manure was applied at the rate of about 8 tons per acre annually. The figures for N. P_2O_5, and K_2O have been calculated on the basis of the average composition of farmyard manure and for CaO on the basis suggested by the writer for exchangeable CaO returned to the soil in farmyard manure. (14). Phosphate was applied as basic slag—annual dressing per acre equivalent to 6 cwt of slag containing 14% P_2O_5. The potassium and nitrogen were applied as kainit and sulphate of ammonia at the rate of 4 cwt and 1 cwt. per acre respectively. Ten tons of ground limestone were applied to plot 5 during the period of experiment.

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*Mechanical Analysis :

Plot 3.—0—9″. Coarse Sand 32.45%. Fine Sand 22.55%. Silt 19.5%. Clay 18.25%.

Plot 8. 0—9″. Coarse Sand 29.80%. Fine Sand 24.50%. Silt 19.5%. Clay 18.5%.

TABLE I.

Manurial treatments, yields, and amount of N, P_2O_5, K_2O, and CaO applied during 15 years.

Plot Number	*Manurial Treatment*	*Approximate amounts of fertilizing ingredients applied during whole period—lbs. per acre*				*Mean annual yield cwts per acre.*
		N	*P_2O_5*	*K_2O*	*CaO*	
1	Farmyard manure annually	1680	340	1440	1120	39.75
2	Farmyard manure and slag alternate years	1000	1130	770	2400	32.50
3	No Manure	—	—	—	—	30.75
4	P annually	—	1340	—	4000	27.00
5	N + P + K annually + $CaCO_3$ every 3rd year	350	1340	880	16500	34.75
6	N + P + K annually	350	1340	880	4000	35.50
7	N + P annually	350	1340	—	4000	31.00
8	No Manure	—	—	—	—	29.00
9	N + K annually	350	—	880	—	33.75
10	P + K annually	—	1340	880	4000	34.75

Observations on the effect of the various manures on the yield of hay and on the botanical composition of the herbage have already appeared in this Journal (9, 10). A final report on these will shortly be published by Dr. R. Alun Roberts. Reference to these observations will only be made in so far as they are explained or illustrated by the figures for chemical analysis. The main conclusions are :—(1) Farmyard manure applied annually is superior to all other treatments. (2) The omission of potash has had a deleterious effect throughout and has become more marked as the years pass. (3) A depression in the yield of hay results from an annual application of slag alone. (4) The addition of ground limestone does not appear to give any additional benefit when applied to a plot receiving annual dressings of a complete fertiliser. This last result was to be expected from the known lime status of this soil.

Analytical Data.

The following data were obtained on the soils.

Total P_2O_5 Determined by the sulphuric acid method of McLean (8).

Citric Acid Soluble P_2O_5 Dyer's 1 % citric method.

Exchangeable CaO and K_2O by extracting with 0.5N acetic acid.

Organic Carbon Walkley and Black Method.

The data for the 0—3″, 3 — 12,″ and 12 — 18″ layers are presented in Table II whilst Table III gives the figures for the 0 — 3,′ 3 — 6,″ and 6— 9″ layers of the two control plots and of the plot treated annually with basic slag. The effect of the manurial treatment on the chemical composition of the soils will be considered separately under the heading of each constituent estimated. In the absence of replications it is necessary to exercise great caution in drawing conclusions from the results of single plots. The general trend of the figures and the mechanical composition of plots 3 and 8 do, however, suggest that the soil is fairly uniform in character.

Phosphorus.

Total P_2O_5 Table II, columns 2, 3 and 4. and Table III, column 3, show the total P_2O_5 in the various layers of the plots. It is evident that addition of manures containing phosphorus has resulted in a considerable increase in the P_2O_5 content of the top three inches of soil in the plots receiving these manures as compared with the three plots receiving no phosphorus. This increase is least in Plot I and is in accordance with the figures shown in Table I for the approximate amounts of phosphorus added in dressings. Five of these plots, Nos. 4, 5, 6, 7, 10, have each been dressed with 1340 lbs.

TABLE II.

Analytical Data on soil layers 0-3″, 3-12″, 12-18″ from Meadow Hay Trial Plots.

Plot No.	% Total P_2O_5			% Citric Acid Sol. P_2O_5			% Exchangeable CaO			% Exchangeable K_2O			% Organic Carbon		
	0-3″	3-12″	12-18″	0-3″	3-12″	12-18″	0-3″	3-12″	12-18″	0-3″	3-12″	12-18″	0-3″	3-12″	12-18″
1	0.249	0.158	0.074	0.024	0.009	0.003	0.289	0.287	0.220	0.011	0.005	0.003	4.81	2.36	0.75
2	0.273	0.167	0.078	0.048	0.015	0.004	0.367	0.289	0.181	0.009	0.006	0.003	4.20	2.28	0.78
3	0.161	0.148	0.074	0.011	0.010	0.003	0.218	0.240	0.193	0.008	0.003	0.002	3.54	2.28	0.75
4	0.284	0.149	0.093	0.052	0.013	0.004	0.412	0.330	0.272	0.011	0.005	0.004	4.18	2.09	1.02
5	0.296	0.194	0.122	0.072	0.021	0.009	0.519*	0.443†	0.389§	0.012	0.004	0.004	4.18	2.63	1.57
6	0.275	0.150	0.120	0.050	0.012	0.008	0.380	0.311	0.262	0.011	0.005	0.004	4.74	2.17	1.35
7	0.308	0.146	0.067	0.066	0.015	0.004	0.423	0.323	0.232	0.010	0.004	0.004	4.59	2.12	0.60
8	0.181	0.139	0.069	0.013	0.009	0.004	0.280	0.293	0.264	0.008	0.004	0.003	4.03	2.20	0.81
9	0.144	0.139	0.072	0.012	0.011	0.004	0.210	0.283	0.255	0.013	0.004	0.006	3.38	2.37	0.89
10	0.273	0.170	0.059	0.066	0.023	0.003	0.428	0.402	0.293	0.007	0.004	0.003	3.93	2.48	0.57

* plus 0.402% CaO as $CaCO_3$
† ,, 0.051% ,, ,, ,,
§ ,, 0.022% ,, ,, ,,

of P_2O_5 during the experimental period. If the mean of these plots are compared with the mean for plots receiving no P_2O_5 viz., plots 3, 8, 9, a mean increase of 0.287—0.162=0.125% is shown in the P_2O_5 content of the 0 — 3′ layers. From measurements made on blocks of soil from the plots it was calculated that the top 3 inches of soil would give 696,300 lbs of air-dry soil passing through the 2mm sieve. It is thus possible to obtain an estimate of the amount of P_2O_5 still persisting in the top 3 inches of soil. This is calculated from these figures to be 870 lbs approx and is about 65 % of the added P_2O_5. Therefore, the greater part of the added phosphorus remains in the top 3 inches of soil.

The figures for the 3 — 12″ layers do not show any apparently significant differences between the plots receiving P_2O_5 and those receiving no P_2O_5. It is probable that a certain amount of P_2O_5 has penetrated into the layers below 3 inches. This would not be apparent in the figures for the analysis of a 9 inch layer as the difference between the treated and untreated plots would be small and liable to be masked by the natural variations of the soil and by sampling errors. Reference to Table III in which figures are shown for the 3 — 6,′ and 6 — 9″ layers of the two control and the slag treated plots suggests a penetration to the 3 — 6 ″ layer and perhaps a little to the 6 — 9″ layer. This is supported by a comparison of the citric acid soluble P_2O_5 figures in Table III, column 4 which, in the control plots, are practically constant throughout, but are very much higher in the top layers of the slag plot. The higher figure in the 6 — 9′ layer, if significant, suggests a penetration to that depth. These data, however, are insufficient to attempt any estimate of the penetration beyond the top 3 inches.

The figures for the total P_2O_5 of the sub-soils are shown in Table II, column 4. Except for plots 4, 5, and 6, they are low and very similar. In view of the data for the 3 — 12″ layers it is unlikely that the higher P_2O_5 content of plots 4, 5, and 6 is due to penetration from the surface layers, but rather to some other cause, either a slight difference in the nature of the sub-soil or to some influence previous to the laying down of these trials. The comparatively high figure for the total P_2O_5 of the 3 — 12″ layer of plot 5 is probably related to this higher content of the sub-soil.

Citric Soluble P_2O_5 These figures run roughly parallel with the total P_2O_5. All the plots which have received the full dressing of basic slag show a figure of 0.05 % or higher as compared with a mean figure of 0.012 % for the plots receiving no phosphate. The mean increase of plots, 4, 5, 6, 7, and 10 over plots 3, 8 and 9 is 0.048 % as compared with 0.125 % for the total P_2O_5 for the same plots. This suggests that about 40 % of the added P_2O_5 retained in the top 3 inches remains soluble in 1% citric acid. Although the citric acid soluble P_2O_5 of the control plots is rather low and a response to phosphate might be expected, it is interesting to note that the addition of phosphate alone has caused a depression in the yield of hay which has become more marked with further applications. The explanation for this may lie in the marked deficiency in available potash of the soil of this field with the consequent ever increasing ratio of available P_2O_5 to available K_2O.

Exchangeable CaO Figures for the exchangeable CaO content of these plots in 1924 are not available but it is clear from the figures for the two control plots that a certain degree of variability in this constituent would have been found at that time. The writer's previous work on the annual loss of lime from the College Farm soils (14, 15) did not include samples from this field because of the possible complications introduced by the existence of these plots. It was found then that for soils of lime status similar to those of the present experiments, an annual loss of about 150 lbs exchangeable CaO per acre from the top 9 inches of soil was to be expected. This over the period covered by the trials would be equivalent to a loss of 2,250 lbs of CaO per acre. This is less than the amount added in the basic slag of the phosphate treated plots (see Table I) and more than that added in the farmyard manure. Thus plots 3, 4 and 9, receiving no calcium should be the most depleted in exchangeable calcium whilst the addition of farmyard manure to plot I should retard the depletion. The remainder of the plots should show a gain in exchangeable CaO at the end of the experimental period. Despite probable variations in the original exchangeable CaO content of the soils the figures in Table II support these expectations. The influence of the added calcium is most apparent in the top 3 inches. It is also evident in the 3 — 12″ layer especially when control plot 3 is compared with the adjacent slag treated plot 4. The figures in Table III for the two control plots and the slag plot show very clearly the increase in exchangeable CaO as the result of the addition of basic slag. It is quite appreciable in all three layers but greatest in the 0—3″ and least in the 6 — 9″ layer.

The figures for plot 5 (Table II) show, throughout the profile, the influence of the dressings of ground limestone. The soils from this plot also contain some residual free calcium carbonate (see footnote Table II). Most of it remains in the top 3 inches but some has penetrated down to the 12 — 18″ layer.

The figures for plot 9 are of interest if compared with the adjacent control plot 8. Plot 9 has received no calcium during the experimental period but has been treated with 15 cwt of sulphate of ammonia and 60 cwt of kainit. The effect of sulphate of ammonia on lime status is now well established. Crowther and Basu (3) have estimated that it is responsible for the loss from the soil of an equal weight of calcium carbonate. On this basis the additional depletion of CaO would be about 940 lbs per acre. In the slag treated plots this effect would be masked by the very much greater addition of CaO in the basic slag. It is, however, clearly observable in the top 3 inches of plot 9, which has an exchangeable CaO of 0.210 % as compared with 0.280 % in control plot 8 and 0.428 % in plot 10 receiving the normal dressing of basic slag but no sulphate of ammonia. The difference in exchangeable CaO between the top 3 inch layers of plots 8 and 9 corresponds to about 490 lbs. CaO per acre, equivalent to more than 50 % of the predicted extra loss due to the sulphate of ammonia. The lower layers of plot 9, also, show a slight fall, but in the absence of information regarding the original lime status of these plots it is unjustifiable to draw any further inferences from these figures. The figures for the whole profile of plot 10 would, however, suggest a greater accumulation of CaO than in the plots whose manurial treatment includes both basic slag and sulphate of ammonia. Plot 5, of course, should be excluded from this comparison.

For the whole series of plots it may be concluded that the figures, in general, indicate a lime status predictable from the treatment and our knowledge regarding the factors influencing the exchangeable CaO content of soils. Generally speaking, increase in yield from lime dressings is not to be expected on soils of this type containing more than 0.20 — 0.25 % exchangeable CaO. This accounts for the lack of response to ground limestone in these experiments.

Exchangeable K_2O

The most striking feature of the hay yield trials on these plots was the marked response to potash whether applied as kainit or in farmyard manure. The superiority of farmyard manure over the other treatments may, in part, be attributed to its greater potassium content (see Table I). The results, therefore suggest a deficiency of available potash (K_2O) in the soils. Most of the chemical methods for evaluating this constituent consist essentially in estimating the exchangeable K_2O. The figures for the profiles are given in Tables II and III. From these results it is evident that, at the time of sampling, all the soils were impoverished in exchangeable K_2O. There does not appear to be any significant difference between the treated and untreated plots. Therefore, the added potassium has either been taken up by the crops or has reverted to non-exchangeable and non-water-soluble form. Very little potassium will have

TABLE III.

Analytical Data for the top layers of plots 3, 4, and 8.

Plot Number and treatment	*Depth*	*Total P_2O_5 %*	*Citric Acid Soluble P_2O_5 %*	*Exchangeable CaO %*	*Exchangeable K_2O %*	*Organic Carbon %*
3	0-3″	0.161	0.011	0.218	0.008	3.54
Control	3-6″	0.150	0.010	0.220	0.006	2.68
	6-9″	0.155	0.010	0.258	0.008	2.40
4	0 3″	0.284	0.052	0.412	0.004	4.18
Basic slag annually	3-6″	0.213	0.034	0.364	0.005	2.82
	6-9″	0.178	0.016	0.341	0.004	2.41
8	0-3″	0.181	0.013	0.280	0.008	4.03
Control	3-6″	0.160	0.012	0.291	0.005	2.54
	6-9″	0.138	0.012	0.296	0.002	2.08

been lost from the soils through leaching. Any water-soluble potassium is included in the figure for exchangeable K_2O as no attempt was made to estimate it separately. A clearer picture of the position may be obtained by converting some of the figures in Table II into lbs. of exchangeable K_2O per acre and comparing them with the amounts removed by crops. The mean for the 0 — 3″ layers (0.01 % K_2O) corresponds to approximately 70 lbs K_2O per acre and that for the 3 — 12″ layer 95 lbs K_2O. Therefore, the total exchangeable K_2O content of the top 12″ of soil is about 165 lbs per acre. These figures may be compared with unpublished data for the exchangeable K_2O of 0—9″ samples taken from plots, 1, 2, 6, 8, and 9 in 1932. No significant difference between the different plots was then to be observed. The mean figure 0.004 % K_2O obtained then suggests a slightly lower exchangeable K_2O content than at the present time. The difference, however, is hardly significant. Strict comparison can only be made in the case of one plot, viz. plot 8. In 1932 the exchangeable K_2O content was 0.004 % whilst in 1940 (see Table III) the mean figure for 0 — 9″ is 0.005 %. It thus appears that over this period of years the exchangeable K_2O status of the plots has undergone very little change. It may be mentioned that this field shows the lowest exchangeable K_2O content of the College Farm fields, which usually contain from 0.014 — 0.025 % K_2O for the top 9 inches. No figures are available for the composition of hay crops actually taken off the plots but a general estimate may be obtained from the average yields and the average composition of meadow hay. The latter is usually quoted as 50 lbs K_2O for a crop of 30 cwt. In these trials the average yields to the nearest cwt were: kainit treated plots 35 cwt; no manure plots 30 cwt.; and the farmyard manured plot 40 cwt per acre. On this basis the K_2O removed per acre from the different plots would be 58.3, 50, and 66.6 lbs respectively. It is likely that the presence of the water-soluble and readily available potassium of the dressings would cause an increased intake of potassium, by the crops on the treated plots resulting in a higher K_2O content per cwt of hay than in the no-manure plots thus giving a greater weight of K_2O removed per acre than these estimates. A further amount of potassium will also have been removed from the soil during the autumn grazing period but the greater part of this will have been returned to the soil as excreta.

From these figures for the exchangeable K_2O of the soils and the K_2O content of the crops it would appear that, normally, in this soil plants derive most of their potassium from non-exchangeable sources, otherwise the total amount of exchangeable K_2O would have been exhausted after 3 crops. It is also clear that the addition of potassic manures in the amounts given in these trials do not have any apparent effect on the exchangeable K_2O. These facts raise two questions, namely, (1) What is the function and importance of the exchangeable potassium in plant nutrition ? and (2) What is the fate of the added potassium ? Is it directly absorbed by the plants in preference to the soil potassium or is it partly absorbed into the exchangeable complex and partly fixed as non-exchangeable potassium ? It is probable that all these possibilities are involved and that the added potassium, 58 lbs and 90 lbs K_2O per acre annually for the kainit and the farmyard manure treated plots, respectively, is not completely recovered by the crop. The soil properties affecting plant nutrition are dynamic and it is likely that after the addition of potash fertilizers a temporary increase in exchangeable K_2O may occur followed later, as the potassium is absorbed by the plants, by a fall to a level necessitated by an equilibrium between the various factors operating in the soil colloidal complex. The evidence in the literature on the availability of soil potassium and its fixation in non-exchangeable forms is very conflicting. Many factors such as type of colloid, degree of saturation, nature of complementary ion in the colloidal complex, moisture conditions, and cropping appear to influence the various relationships. But it would be generally agreed that the amount of exchangeable K_2O serves as an index of fertilizer needs. Schachtschabel (13) has shown by pot experiments that the exchangeable form is first taken up by plants and the non-exchangeable later. The same worker (12) and others conclude that the chief source of the latter form of potassium appears to be the micas of the soil material and not felspars. No general agreement has been reached as to the amount of exchangeable K_2O for satisfactory plant growth. Gesiger (4) suggests 0.025— 0.05 % for acid soils and 0.015—0.023% for neutral soils. The lower level for neutral soils is in agreement with the theories of Jenny and Ayer (7) mentioned later. They suggest that the exchangeable potassium is more available in calcium saturated soils than in acid soils. Allway and Pierre (1) on the other hand state that the high-lime soils of Iowa require more exchangeable potassium to support good crop growth than do their normally acid soils. In general it may be said that the lower the degree of potassium saturation of the soil exchange complex the greater the yield increase brought about by the application of potash fertilisers. Jenny and his collaborators (5, 6, 7) have recently studied the problem of absorption of exchangeable potassium by plants and have developed the theory of contact exchange which provides an additional mechanism for the accumulation of ions by plants. According to this theory direct exchange of ions can take place between plant root surfaces and the colloidal particle touching them. They maintain that above a certain critical degree of potassium saturation roots may accumulate potassium ions from the colloid and lose them below it. It is suggested that the critical degree of saturation is not a fixed property of the soil, but depends on the type of plant and its physiological conditions.

The low exchangeable K_2O content of the soils under discussion in the present work would ensure their classification as deficient under any of the suggested standards for exchangeable K_2O. Their degree of potassium saturation, about 1% of their base exchange capacity, may, quite possibly, be about or even below the critical degree of saturation postulated by Jenny and Ayer. It would be expected, however, that the continued application of potash fertiliser would have resulted in some increase to their exchangeable K_2O content. This has not occurred and, therefore, any added potassium not absorbed by the plants must have been fixed in a non-exchangeable form. The evidence in the literature suggests that this is most probable. Schachtschabel (11) found that soils which originally did not fix added potassium in a non-exchangeable form, when treated with a potassium salt solution, were able, after growing a succession of Neubauer seedlings, removing 100 mg. K_2O per cent, to fix 60 mg. K_2O per cent in a non-exchangeable form. Numerous other workers have studied and demonstrated this type of fixation. Chaminade (2) for a series of French soils found no fixation occurred when the amount of exchangeable K_2O was more than 4% of the total exchange capacity of the soil. As this value exceeds that of most agricultural soils some fixation is generally to be expected. In the present case of about 1% saturation quite appreciable fixation may be expected.

The results of the present experiments and the evidence in the literature show that although exchangeable potassium is by no means the only source of soil potassium for plant growth, yet its amount gives a valuable indication of the more readily available potassium. When it is low the plants will have to depend almost wholly, as in the case of the no-manure plots, on the less available non-exchangeable form. In the present experiments the potassium added in fertilisers is not reflected in the exchangeable base content of the soil, but is either absorbed by the plants or is fixed in a non-exchangeable form.

Organic Carbon. The figures for organic carbon are given in the last three columns of Table II and the last column of Table III. There does not appear to be any general relationship between these figures and the manurial treatment or with any of the figures for the other constituents. As expected the farmyard manure plot shows the highest organic carbon figure of the 0—3" layers. With regard to the other plots a low lime status appears to be associated with the lower organic carbon contents (viz., plots 3 and 9). In the 3—12" layers high lime status and high citric acid soluble P_2O_5 are associated with the highest organic carbon figures (plots 5 and 9). This association between citric acid soluble P_2O_5 and organic carbon content is also apparent in the 12—18" layers of plots 5 and 6.

Summary.

Data are given for the total P_2O_5, citric acid soluble P_2O_5, exchangeable CaO, exchangeable K_2O, and organic carbon for profile soil samples from plots at the conclusion of a 15-year manurial experiment on meadow hay. The cumulative effect on soil composition of the main constituents of the manures and fertilisers is discussed.

The results suggest that about 65% of the total P_2O_5 of the added basic slag is retained by the top 3 inches of soil. About 40% of this remains in a form soluble in 1% citric acid. Although there is some evidence of penetration of P_2O_5 to lower layers, the data are insufficient to permit an estimate of its extent being made.

The figures for exchangeable CaO are in accordance with expectation. The plots dressed with manures containing available lime show higher exchangeable CaO contents throughout the profiles. This effect is most marked in the upper layers of the soil and on the plots receiving the highest dressings of calcium, particularly the plot receiving ground limestone every third year.

The lack of yield response to manures containing lime was to be expected in view of the original lime status of the soil.

The figures for exchangeable K_2O are of particular interest in view of the fact that the yield trials showed a marked response to potash fertilisers On the basis of their exchangeable K_2O content all the plots show potash deficiency and continuous manuring with potash fertilisers does not appear to have brought about any significant permanent improvement in this respect. It is suggested that the added potash is partly taken up by the crop and partly fixed by the soil in a non-exchangeable form.

References.

1. ALLWAY, H., and PIERRE, W. H. 1939. *J. Amer. Soc. Agron.* 31, 940.
2. CHAMINADE, R. 1936. *Compt. Rend.* 203, 682.
2a. ——————... 1936. *Ann. Agron.* 6, 818.
3. CROWTHER, E. M., and BASU, J. K. 1931. *J. Agric. Sci.* 21, 196.
4. GESIGER, L. 1937. *Bodenk. Pflanzenernahr.* 2, 23.

5. Jenny, H., and Overstreet, R. 1939. *Soil Sci.* 47, 4, 257.
6. Jenny, H. Overstreet, R. and Ayers, A. D. 1939. *Soil Sci.* 48, 1, 1.
7. Jenny, H., and Ayers, A. D. 1939. *Soil Sci.* 48, 6, 443.
8. McLean, W. 1936. *J. Agric. Sci.* 26, 331.
9. Roberts, R. A., Roberts, E. J., and Lewis, I. G. 1931. *Welsh J. Agric.* 7, 142.
10. Roberts, R. A., and Thomas, J. O. 1934. *Welsh J. Agric.* 10, 165.
11. Schachtschabel, P. 1937. *Bodenk. Pflanzenernahr.* 3, 107.
12. ———————— 1938. *Ernahr. Pfl.* 34, 129.
13. ———————— 1939. *Ernahr. Pfl.* 35, 132.
14. Williams, Rice. 1936. *Empire J. Expt. Agric.* 4, 61.
15. ———————— 1937. *Welsh J. Agric.* 13, 246.

THE INFLUENCE OF LIMING ON THE HERBAGE OF ACIDIC SOILS IN MERIONETHSHIRE.

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Only those aware of the state to which our land had been brought to through its depletion of lime can appreciate how welcome to the farming community was the Ministry of Agriculture's subsidy for the purchase of lime and slag. Farmers knew well how sadly their soils stood in need of lime, and the manner in which they have taken advantage of the land fertility scheme is the strongest evidence of this.

Prior to the introduction of the subsidy, the prevailing price of lime made it an economic impossibility to satisfy the soil's requirements, although a few kept up their custom of liming small areas. The consequences of this are reflected in the nature of the soils that have been investigated in Mid-Wales under the Land Fertility and Soil Survey Schemes for the year ending September, 1939. Thus of the two thousand soils examined during this period, 94 per cent were found to be acidic, and in a high proportion of them the acidity was so intense that a liberal dressing of lime was the first essential for satisfactory crop production. The good effects following the liming of these soils are due to the improvements brought about in their physical, chemical and biological properties. The improvement in their texture and reduction in acidity as a result of liming brings about a beneficial influence on the soil micro-organisms. This increase of biological activity has a profound effect on the chemical properties of the soil, which in turn influences the chemical composition of the plant, and any factor that tends to improve the composition of the food offered to the grazing animal is a matter of the utmost importance. The prominent position of stock raising and the increase in the production of milk in our area demand herbage of such a quality as to give the animal a satisfactory protein and mineral supply. It is with the influence of liming on the concentration of these and other chemical constituents in the herbage that this paper is primarily concerned.

There are important variations in the composition of herbage plants that depend on other things than soil conditions. This was early realised as a result of work carried out at Aberystwyth, where it was found that some species and strains of plants, which, although growing on the same soil, became richer in essential chemical constituents than others. This must be largely attributed to a difference in the food abstracting power of the various grasses and clovers, some being able to utilise the same available constituents more efficiently than others. For example, if perennial rye grass and cocksfoot are taken as our standard grasses, in that both contain a high percentage of nitrogen, phosphoric acid and lime, we find that under the same soil conditions meadow foxtail contains a higher percentage of nitrogen than either of these, but a much lower percentage of phosphoric acid and lime. Again, tall oat grass contains a higher percentage of phosphoric acid, but is not so rich in nitrogen and lime, while red fescue is among the richest in lime, but is poor in nitrogen and phosphoric acid. Clovers on the other hand, contain a much higher percentage of nitrogen and lime than any of the grasses, but their phosphoric acid content is something similar. Not only are differences of this nature found between one grass and another, but significant differences are found between strains of one and the same grass, e.g., between indigenous and commercial varieties of cocksfoot, timothy and tall oat grass.

Both the plant and the soil are, however, responsible for the great fluctuations met with in the percentage of crude protein, phosphoric acid and lime in the dry matter of the herbage in the area. These fluctuations are shown in Table I.

TABLE I.

The Compositions of Typical Pastures in Mid Wales.

Type	1	2	3	4	5
Crude protein	21.69	18.13	15.13	12.38	9.81
Phosphoric Acid (P_2O_5)	0.94	0.76	0.59	0.44	0.26
Lime (CaO)	1.26	1.12	0.81	0.39	0.32

1, 2 and 3 may be taken as typical of lowland pastures found in Mid-Wales, with 2 and 3 predominating. 4 represents the " ffriddoedd " of upland districts, while 5 may be taken as representative of a large area of the sheep walks. The grazing animal in those districts where pastures 1, 2 and 3 predominate are amply safeguarded against inadequate supplies of protein and mineral matter. Pastures 4 and 5, while containing a lower concentration of protein than the first three, show even a greater divergence from them when we consider their poverty in mineral matter. Increases in the concentration of protein and particularly of the lime and phosphate in the mineral matter of these hill pastures are highly desirable to ensure an adequate nutrition level for the animals that graze them. The influence of lime in the form of ground lime and ground limestone is well illustrated in a series of experimental plots laid out by two of the present writers (Jones and Williams) in Merionethshire.

These plots are situated at altitudes ranging from sea level to over 700 feet, are distributed over the county and vary in acidity from pH 4.0 to 5.6. At each centre there are three plots (a) control, (b) dressed with ground burnt lime, and (c) dressed with an equivalent weight of ground limestone. All the plots were laid out early in 1938 and each had received a dressing of lime or limestone before the end of March in that year. Subsequent to that date one or more samples of the herbage from all the plots at each centre have been taken and subjected to chemical examination.

Table II indicates the acidity and lime requirement of the soils at the different centres selected for the experiment, the particulars regarding the application of different forms of lime, and the dates when the herbage was cut.

TABLE II.

Particulars of Experimental Centres with Time of Liming and Dates when herbage was cut.

Name of Centre.	*Altitude*	*Soil pH*	*Lime Requirement**	*Time of liming*	*Tons per acre*		*Date of Cutting*
					Groundlime	*Limestone*	
Fegla Fawr, Arthog	25	4.0	10	Mar., 1938	1.25	2.25	19 : 11 : 38 7 : 7 : 39 15 : 9 : 39
Cefn Clawdd, Hafodoer	775	4.3	8½	do.	1.5	2.6	5 : 5 : 39
Cefnrowan Isaf, Islawrdref	550	4.5	7	do.	1.5	2.6	14 : 9 : 38 7 : 7 : 39
Trwyn-y-garnedd, Maentwrog	40	4.6	7	do.	1.65	2.9	19 : 11 : 38 14 : 9 : 39
Caerddaniel, Llanbedr	20	5.2	3½	do.	2.0	3.5	21 : 10 : 38
Maesgwyn, Gwyddelwern	700	5.4	3	do.	2.0	3.5	7 : 7 : 39
Glandwr, Llanuwchllyn	550	5.6	4	Jan., 1938	1.4	2.5	19 : 11 : 38

*Tons Calcium Carbonate per acre. Hutchinson and McLennan Method.

It is seen from the above that while there were great variations in the acidity of the soils at these centres, only moderate dressings of lime were applied even to the most acid of them. One of the main objects was to determine the effect produced by a moderate dressing of lime and limestone on a soil having a high lime requirement. This accounts for the fact that the lime application given to some of the more acid soils has been no heavier than that applied to those showing less acidity.

The following table shows the effect of the liming on the chemical composition of the herbage from the Fegla Fawr centre, from which, as already mentioned, cuts were taken on three different dates.

TABLE III.

Gives the average composition of the three cuts from each plot, and the effect of Lime and Limestone on the protein and mineral content of the herbage* at Fegla Fawr.

				Percentage increase due to	
	Control	*Ground Lime*	*Ground Lime-stone*	*Ground Lime*	*Ground Lime-stone*
Crude protein	10.82	13.85	13.44	28	24
Silica free ash	3.37	5.02	5.36	49	59
Phosphoric Acid (P_2O_5)	0.28	0.43	0.39	53	39
Lime (CaO)	0.37	0.66	0.79	78	113
Potash (K_2O)	2.05	2.69	2.37	31	15

*All constituents in the above and following tables are expressed as percentage of dry matter.

These plots at Fegla Fawr were laid out on an old rough peaty pasture, the herbage consisting chiefly of inferior grasses and moss with only a trace of wild white clover. The chemical composition of the herbage shows it to be on a par with the poorest type of herbage given in Table I, being extremely low in crude protein, phosphoric acid and lime. On the treated plots there was a marked though uneven improvement, the herbage in parts being obviously more succulent and containing a fair amount of wild white clover and trefoil. Both the treated plots were better grazed than the unmanured. From Table III it is seen that a moderate dressing of lime in the form of either ground lime or limestone has effected a pronounced increase in the crude protein. The most important change in the mineral matter from a nutrition standpoint is the increase in the percentage of lime and phosphoric acid.

As the untreated soil is low in available calcium, an increase in this constituent of the herbage was to be expected as a result of the application of lime. It is of interest to note that the effect of liming is not restricted to this mineral constituent, for a moderate dressing of lime has also increased the availability of the soil phosphate to the plant, the low availability of which in the control plot was evident both from an analysis of the soil and of the herbage growing on it. The only mineral constituent determined in the soil and found present in adequate amounts was the available potash, but here also liming is seen to have increased the potash content of the herbage.

The next table shows the effect of liming on the herbage of the centre at Cefn Clawdd, another exceptionally acid soil, though somewhat less acid than the peat at Fegla Fawr.

TABLE IV.

Showing the effect of liming on the chemical composition of the herbage at Cefn Clawdd.

				Percentage increase due to	
	Control	*Ground Lime*	*Ground Lime-stone*	*Ground Lime*	*Ground Lime-stone*
Crude protein …… ……	10.80	15.90	13.30	47	23
Silica free ash …… ……	4.22	4.87	7.26	15	72
Phosphoric Acid (P_2O_5)……	0.66	0.81	0.91	22	38
Lime (CaO) …… ……	0.77	0.88	1.21	14	57
Potash (K_2O) …… ……	1.56	1.38	2.40	—	53

The herbage at this centre was similar to that at Fegla Fawr in having an exceptionally low percentage of protein, but differed markedly from it in its higher percentage of lime and phosphate. The effect of liming on the protein content has been similar to that at Fegla Fawr in that at both centres a considerable increase in this constituent has followed the application of the different forms of lime.

While the effect of liming on the potash of the plant is somewhat uncertain at this centre, the lime and phosphate of the herbage have increased as a result of the application of both forms of lime.

In the following table the mean values for the two cuts taken at the next centre, Cefnrowan Isaf, are given.

TABLE V.

Showing the effect of Lime and Limestone on the composition of the Herbage at Cefnrowan Isaf.

				Percentage increase due to	
	Control	*Ground Lime*	*Ground Lime-stone*	*Ground Lime*	*Ground Lime-stone*
Crude protein	12.75	16.15	15.75	26	23
Silica free ash	4.16	5.56	6.52	33	56
Phosphoric Acid (P_2O_5)......	0.50	0.59	0.77	16	54
Lime (CaO)	0.41	0.80	0.91	95	122
Potash (K_2O)	2.40	2.68	3.06	12	27

The herbage of the control plot at the above centre more closely resembles in chemical composition that of a good " Ffridd " than a third class lowland pasture. While it is superior in protein to that of the two previous centres, it is inferior to that of Cefn Clawdd in lime and phosphate and little better than the herbage at the first centre (Fegla Fawr) in lime. The herbage on the ffridd consisted mostly of bent grass, fine leaved fescue, Yorkshire fog, mosses and a trace of wild white clover. There was not much visible improvement in the nature of the herbage in either of the dressed plots, except that the treated herbage was more succulent and the moss had been considerably reduced. The ground burnt lime plot was decidedly better in appearance than the ground limestone plot, but wild white clover had not increased to any appreciable extent in either. In spite of the small changes in botanical composition the crude protein has again been greatly increased by the application of lime, and the mineral content has also been favourably influenced, the lime to a greater extent than at any of the preceding centres.

The next centre to be dealt with is that of Trwynygarnedd, where the acidity and lime requirement of the soil are similar to those of the last centre, Cefnrowan Isaf. Mean figures are shown for the two cuts taken from each plot.

TABLE VI.

Effect of Lime and Limestone on the composition of the herbage at Trwynygarnedd.

				Percentage increase due to	
	Control	*Ground Lime*	*Ground Lime-stone*	*Ground Lime*	*Ground Lime-stone*
Crude protein	13.67	16.82	15.00	23	9
Silica free ash	3.47	6.13	5.32	76	53
Phosphoric Acid (P_2O_5)......	0.49	0.62	0.49	26	—
Lime (CaO)	0.36	0.96	0.99	166	175
Potash (K_2O)	2.29	2.75	2.40	20	4

Judging from the herbage improvement as observed in the field, the ground burnt lime has to date given better results than the limestone at the above centre. The herbage in the control plots consists of a mixture of bent, fine leaved fescue, nardus, sedge, sorrel and moss with a trace of wild white clover, red clover and birdsfoot trefoil. In 1939 there was a marked improvement in the grazing on the treated plots, and a pronounced reduction in the moss. The wild white clover content on the ground burnt lime plot increased very considerably by the summer of 1939, and the improvement was still more marked in the spring of 1940. The results were not as satisfactory on the ground limestone plot. The response of the wild white clover was much less marked, but trefoil and wild red clover were fairly abundant in patches.

The soil at this centre was of a peaty character, but the herbage has a slightly higher protein content than that of the previous centre. The mineral content of the untreated sward still remained low, and the influence of both lime and limestone upon it is very similar to that at Cefnrowan Isaf. The one noteworthy difference is that the phosphoric acid has not been affected by the limestone.

The effect of the lime and limestone at the centres so far dealt with is on soils with a high degree of acidity (pH 4.0 to 4.6), whereas the soils of the three remaining centres showed a lower degree of acidity (pH 5.2 to 5.6).

The composition of the herbage of the plots of these three centres is shown in Table VII, together with the percentage increase of each constituent resulting from the application of both forms of lime.

TABLE VII.

Showing the change in chemical composition of the herbage effected by the application of lime and limestone at Caerddaniel, Maesgwyn and Glandwr.

	Control	*Ground Lime*	*Ground Lime-stone*	*Percentage increase due to*	
				Ground Lime	*Ground Lime-stone*
Caerddaniel.					
Crude protein	18.41	21.62	20.85	17	13
Silica free ash	7.21	6.11	8.81	—	22
Phosphoric Acid (P_2O_5)......	0.79	0.66	0.68	—	—
Lime (CaO)	0.74	0.95	1.04	28	40
Potash (K_2O)	2.58	2.31	2.14	—	—
Maesgwyn.					
Crude protein	15.90	14.80	15.10	—	—
Silica free ash	5.64	6.78	6.05	20	7
Phosphoric Acid (P_2O_5)......	0.59	0.56	0.63	—	6
Lime (CaO)	0.87	1.16	1.18	33	35
Potash (K_2O)	2.54	2.14	2.40	—	—
Glandwr.					
Crude protein	13.23	15.34	13.74	15	3
Silica free ash	5.11	5.84	5.78	14	13
Phosphoric Acid (P_2O_5)......	0.55	0.61	0.61	10	10
Lime (CaO)	0.81	0.96	1.07	18	32
Potash (K_2O)	1.76	1.68	1.29	—	—

Judged by the chemical composition of the herbage of the three control plots at these centres, Caerddaniel, apart from its low lime content, is in all other respects typical of the second class pastures of Mid-Wales, while those of Maesgwyn and Glandwr more closely resemble the third class.

The soils of the three centres were fairly well supplied with available phosphate and potash ; that of Caerddaniel being richer in phosphate, while that of Maesgwyn was the lowest in potash.

In connection with the mineral matter of the herbage, its lime content has been increased in all the lime and limestone plots. Liming, however, at the soil acidity levels obtaining at these three centres, cannot be said to have increased the availability of the phosphoric acid, while its effect on the potash has been to diminish its concentration in the herbage.

Conclusions.

The result of the application of lime and limestone on the chemical composition of the herbage has been :—

(*a*) To increase the protein content of that of all plots, with the exception of one of the less acid plots (Maesgwyn).

(*b*) To increase the lime content of that of all plots.

(*c*) To, on the whole, increase the phosphoric acid and potash on those plots with a high acidity, the former to a greater extent than the latter.

(*d*) At the three centres last discussed, where the acidity is not so high, the effect of liming on the phosphoric acid has been small, while it has lowered the concentration of potash.

(*e*) The work is still in progress in order to find the significance of those differences observed at some of the centres, in the behaviour of the plots receiving equivalent quantities of lime and limestone.

INDIGENOUS PERENNIAL RYE-GRASS* AND COMMERCIAL STRAINS OF MEADOW FESCUE, COCKSFOOT AND TIMOTHY IN SIMPLE MIXTURES.

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The behaviour of the species and strains under discussion in this paper in the first and second harvest years has already been reported upon by Stapledon and Davies (1).

The primary purpose of the experiment (E.61.II sown 1925) was to test various strains of red clover in simple mixtures.

The contribution of most of the red clovers to the herbage in the third harvest year was negligible. Subsequent observations, therefore, were concerned mainly with the relative persistency of the wild white clover, and of the species and strains of grasses which were sown in the various mixtures. The evidence in this paper deals with the fourth and subsequent harvest years.

The trials were laid down at two upland and three lowland centres. Details of the centres are given hereunder :—

Centre	*Elevation*	*Soil type*	*Nurse crop*	*1924 and 1925 Manurial treatments*
UPLANDS.				
Pensarn, Talybont, 1	700 ft.	Light loam	Oats	1924 : Farmyard manure and superphosphate 1925 : Slag.
Moelglomen, Talybont, 2	600 ft.	do.	Barley	1924 : Farmyard manure and superphosphate
LOWLANDS.				
Penybank, Llangybi, 3	500 ft.	Heavy loam	Rape and hardy green turnips	1924 : Farmyard manure 1925 : Lime and slag
Pengraig, Llanfarian, 4	250 ft.	Light loam	Oats	1924 : Farmyard manure and vetches ploughed in
Nantsiriol, Bow Street 5	50 ft.	Heavy loam	Barley	1924 : Farmyard manure and superphosphate 1925 : Slag

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*Ex old pasture.

Centres 1 and 2 are regarded as " upland " partly on account of their elevation, but mainly because they form part of the cultivated land on two typical hill farms. The fields under consideration are at a low altitude in comparison with most of the land on the two farms. The soil, however, is thin and stony. Usually the young leys are grazed to excess in the spring.

The data under review represent three systems of management :—

(*a*) Centres 1 and 2, Uplands ; severe and prolonged spring grazing, each year up to early May. The fields were then closed for hay and the hay crop was cut late—middle to end of July.

(*b*) Centres 3 and 4. Lowlands ; hay was harvested in the first year only. The fields were grazed in subsequent years, and no hay crop was taken.

(*c*) Centre, 5 Lowlands ; severe spring grazing (but light grazing relative to the uplands) until April each year. The field was then put up to hay and the crop was cut about the end of June to early in July.

The Mixtures.

Nine different mixtures were sown, while a tenth plot was sown with red clover only. Particulars of the mixtures are given in Table 1. The plots were 1/10th acre in extent.

TABLE I.

Seeds mixtures used, in lb. per acre.

	Mixtures					
Species and strain	1 & 6*	2 & 7*	3 & 8*	4 & 9*	5**	10**
Perennial rye-grass (indigenous)	14	—	—	—	6	—
Meadow fescue (commercial)	—	14	—	—	—	—
Timothy (commercial)	—	—	14	—	4	—
Cocksfoot (commercial)	—	—	—	14	8	—
Rough-stalked meadow grass (commercial)	2	2	2	2	2	—
Wild white clover (Kent)	1	1	1	1	1	—
Red clover	6	6	6	6	6	6

*Four replications. **Two replications.

Mixtures 1 to 4 and Mixtures 6 to 9 contained also Italian rye-grass at the rate of 4 and 12 lb. per acre, respectively. After the second year the amount of Italian rye-grass on the plots was negligible, and therefore the mixtures differing only in the amount of Italian rye-grass which was sown were treated as replicate since the botanical composition of the plots was very similar.

Discussion of Results.

Fourth Harvest Year (1929).

The botanical composition of the plots is given in Table II. Separate average figures are given for the upland and lowland centres.

The figures for perennial rye-grass in Mixtures 1 and 6, and Mixture 5, include " sown " and " unsown " (volunteer) perennial rye-grass. Commercial perennial rye-grass was not included in the trial.

The Upland Centres.

By the fourth year all the sown species, except indigenous perennial rye-grass and wild white clover, had almost completely died out. The plots were dominated by unsown species, mainly Yorkshire fog, *Agrostis* spp., sweet vernal grass and crested dogstail. Commercial meadow fescue persisted rather better than commercial strains of cocksfoot and timothy, but all three species were poor. Rough-stalked meadow grass was a failure.

The Lowland Centres.

Commercial cocksfoot and commercial timothy were not a success. Commercial meadow fescue persisted in appreciable amount. The figures, however, do not indicate that it is a highly persistent species. Indigenous perennial rye-grass was an outstanding success and this was the most striking feature of the trial. Even on the plots where indigenous perennial rye-grass was sown at the low rate of 6 lb. per acre (Mixture 5) in conjunction with commercial strains of cocksfoot and timothy it made a high percentage contribution to the herbage. Indigenous perennial rye-grass makes slow spring growth ,and it is probable that the commercial cocksfoot afforded a certain degree of protection to it in the second year. Rough-stalked meadow grass was very successful, and with wild white clover it helped to form a dense close sward. The data show that perennial rye-grass, rough-stalked meadow grass and wild white clover are capable of making appreciable " unsown " entry on good lowland soils. On the plots which were sown with red clover only the combined contribution of these valuable plants, on a tiller basis, is as high as 61 per cent, the

TABLE II.

Showing the percentage contribution (tiller estimations) of the species and strains in September 1929, the fourth harvest year. Average of three lowland centres and two upland centres.

Species and strain	*Mixtures*											
	1 and 6		*2 and 7*		*3 and 8*		*4 and 9*		*5*		*10*	
	Lowlands	*Uplands*	*Lowlands*	*Uplands*	*Lowlands*	*Uplands*	*Lowlands*	*Uplands*	*Lowlands*	*Uplands*	*Lowlands*	*Uplands*
Perennial rye-grass ("sown" and "unsown")	63	16	—	—	—	—	—	—	55	15	—	—
Perennial rye-grass (unsown = volunteer)*	—	—	19†	1†	22†	Trace†	23†	Trace†	—	—	29†	2†
Meadow fescue (commercial)	Trace†	—	16	4	1†	—	—	—	—	—	—	Trace
Timothy (commercial)	Trace†	—	Trace†	Trace†	4	1	Trace†	—	1	Trace	Trace†	—
Cocksfoot (commercial)	Trace†	Trace†	Trace†	Trace†	—	—	4	2	2	Trace	Trace†	Trace
Rough-stalked meadow grass	23	2	43	3	49	5	51	7	32	3	24†	3†
Wild white clover	11	10	14	10	16	20	14	20	8	21	8†	14†
Unsown "weed" species	3	72	8	82	8	71	8	71	2	59	39†	81†

†Unsown = volunteer

*On good soils perennial rye-grass plants often establish in appreciable quantity on plots or fields where the species has not been sown. The "unsown" seeds make their appearance in a variety of ways, but chiefly, perhaps, from seed shed under hay conditions.

remainder being made up of inferior species. The figure for rough-stalked meadow grass is very much lower on the indigenous perennial rye-grass plots. On account of its own persistency and habit of growth, the rye-grass prevented rough-stalked meadow grass from gaining too much ground. Frequent seasonal observations indicated that rough-stalked meadow grass blended well with indigenous perennial rye-grass and wild white clover to form a dense sward free from bare ground. It is evident that in the autumn on good soils rough-stalked meadow grass may occupy a high percentage of ground, and its rapid spread when it is sown with low tillering, non-persistent plants such as commercial strains of cocksfoot and timothy prevents the ingress of undesirable species.

The plots which were sown with commercial strains of meadow fescue, timothy and cocksfoot contained only 9 per cent of unsown species, while the corresponding figure for the indigenous perennial ryegrass plots was as low as 3 per cent. As a weed suppressor, therefore, on good soils well supplied with moisture, rough-stalked meadow grass is very valuable. The high percentage of weeds on the plots sown with red clover only shows how important it is to sow rough-stalked meadow grass and wild white clover rather than to wait for their " unsown " appearance.

The low tillering commercial strains of cocksfoot and timothy in the absence of prolonged competition from perennial rye-grass, usually establish successfully, and show up well in the second year. They do not, however, persist when subjected to a system of management which involves severe defoliation in the spring, even under reasonably good soil conditions.

Observations subsequent to the Fourth Harvest Year.

The Upland Centres.

Both the upland centres were ploughed in 1932, the seventh harvest year. Observations made on the plots in 1931 indicated that reversion was almost complete. Both wild white clover and indigenous perennial rye-grass, however, continued to contribute in small amounts.

The Lowland Centres.

Observations were made periodically at the three lowland centres.

Tenth Harvest Year, 1935.

At the lowland grazed centres the persistency of indigenous perennial rye-grass continued to be excellent, and the plots at one centre (Centre 3) had hardly deteriorated at all botanically. They were grazed closely and they were completely free from tufts. At this centre the plots were sown under rape and hardy green turnips, and a heavy dressing of lime was applied to the field in the spring of the seeding year, 1925. " Unsown " perennial rye-grass was present on the plots at both centres, but the percentage on the " sown " plots was about twice as high as on the " unsown " plots (approximately 50 per cent as compared to 25 per cent).

The plots on which the rate of seeding of indigenous perennial rye-grass was low (Mixture 5) continued to maintain a weed-free sward which was very little inferior to the plots which were sown at the higher seed rate (Mixtures 1 and 6). The indigenous perennial rye-grass plots could still be recognised easily by their characteristic dark green colour. There was very little *Agrostis.*

At the lowland centre from which a succession of hay crops had been taken for several years, there was an appreciable percentage of Yorkshire fog. The margin of difference between the percentage of " sown " perennial rye-grass and the " unsown " perennial rye-grass was not so great as at the grazed centres. Both rough-stalked meadow grass and wild white clover, however, were present in quantity and helped to maintain a good sward.

At Centre 4 (light loam) the content of rough-stalked meadow grass and wild white clover fluctuated far more than at Centres 3 and 5 (heavy loam) during the summer. This was probably due to the more definite effect of drought on the light rather thin loam than on the heavy loam.

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Reference.

1. STAPLEDON, R. G., and DAVIES, WILLIAM. Seeds Mixture Problems: Competition. *Welsh Plant Breeding Station Bulletin,* Series H. No. 8. pp. 64-76. 1928.

SEED MIXTURE EXPERIMENT (1927) SOWN.

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The experiment (E.76I.) was designed to test:

(1) Montgomery red clover, English late-flowering red clover and broad red clover as hay.

(2) Indigenous and commercial strains of cocksfoot and perennial rye-grass.

(3) Crested dogstail and rough-stalked meadow grass.

(4) Varying seed rates of wild white clover.

(5) Wild white clover *versus* Dutch white clover.

The experiment was laid down at three centres:

Centre 1, Lowlands: heavy loam, 50 ft. above sea-level (Nantsiriol).
,, 2, Uplands: very thin soil, 700 ft. above sea-level (Pensarn).
,, 3, ,, moderately thin soil, 850 ft. above sea-level (Moelglomen).

The plots were 1/10th acre in size and were duplicated at each centre. In each case the seeds were sown under a cereal nurse crop in April, 1937.

The Mixtures.

Ten mixtures were included in the trial at each centre. One mixture (Mixture 10) was similar in type to the mixtures used by farmers in West Wales at the time the experiment was laid down, and was made up completely of commercial strains. The other mixtures were designed for special purposes and were not necessarily in keeping with any standard mixture.

Particulars of the mixtures used are given in Table I.

Material and Methods.

Hay was taken at each centre in the first harvest year. In the second harvest year one of the upland centres was treated as pasture and no hay was taken.

Notes were taken of the standing hay crop at each centre in the first harvest year. In the second harvest year representative samples of the herbage were taken at the two hay centres while during the same month detailed notes were taken at the centre which was treated as pasture. The hay samples were botanically analysed, using the percentage productivity estimation method for the purpose (1).

TABLE I.

The seeds mixtures used, in lb. per acre.

Species and Strain	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Italian rye-grass	4	4	4	4	4	4	4	6	6	10
Perennial rye-grass (indigenous)*	—	14	—	20	5	5	—	20	20	—
Perennial rye-grass (commercial)	14	—	20	—	—	—	14	—	—	14
Cocksfoot (station-bred)	—	8	—	—	—	20	9	—	—	—
Cocksfoot (commercial)	8	—	—	—	20	—	—	—	—	2
Timothy (commercial)	4	4	—	—	—	—	8	—	—	2
Rough-stalked meadow-grass	1	—	1	—	3	—	2	3	3	—
Crested dogstail	—	1	—	1	—	3	2	3	3	—
Montgomery late-flowering red clover	6	6	3	3	2	2	—	6	6	—
English late-flowering red clover	—	—	3	3	2	2	6	—	—	2
Broad red clover	—	—	—	—	2	2	—	—	—	4
Alsike	—	—	—	—	—	—	—	—	—	1½
Wild white clover	½	½	½	½	1	1	2	½	3	—
Dutch white clover	—	—	—	—	—	—	—	—	—	1

**Ex* old pasture.

The lowland centre was ploughed in the spring of 1930, the third harvest year. All the analytical data after the second harvest year were collected at the upland centre from which hay was taken in the first harvest year, and which was grazed in subsequent years (Centre 3). Pasture analyses *in situ* were carried out either by the "tiller estimation" method or the "percentage ground cover" method (1).

Discussion of Results.

1928—*First Harvest Year Hay.*

Detailed notes were taken at all the centres immediately before the hay was cut. Montgomery red clover was not in flower, but it made a much denser stand than English late-flowering red clover and broad red clover. The plots containing Montgomery red clover were the most productive at all the centres. Alsike was poor, crested dogstail and rough-stalked meadow grass compared favourably with perennial rye-grass, especially at the lowland centre. Danish cocksfoot was more advanced in growth than Station-bred cocksfoot, but the latter produced an appreciable amount of leafage which filled in well at the base. Wild white clover was more prominent at the upland centre than at the lowland centre. Italian rye-grass was not a significant contributor.

1929—*Second harvest year hay*: *Centres* 1 *and* 2.

Hay was taken at one upland centre and at the lowland centre. The percentage productivity estimations of the various species and strains contributing to the hay crop (average of all plots) are given in Table II.

The figures, based on the botanical analyses of representative samples, refer to "proportional" yield and not to "actual" yield.

Indigenous perennial rye-grass and commercial perennial rye-grass have not been treated separately because the figures for each were very similar. It is important to note, however, that the indigenous strain was, in most of the mixtures, in competition with crested dogstail, whereas the commercial perennial rye-grass was in competition with rough-stalked meadow grass. Observation notes indicated that the commercial cocksfoot was not denser than the Station-bred cocksfoot, but that it was at a more advanced stage of growth. Timothy contributed rather better than cocksfoot. Rough-stalked meadow grass was not nearly so productive as in the first harvest year. At the upland centre crested dogstail competed very strongly with perennial rye-grass. This aggressiveness of crested dogstail as hay in the second harvest year on thin soils has been demonstrated in other experiments (2). The red clovers did not persist so well at the upland centre as on the lowland. Wild white clover was more prominent at the upland centre. This is a valuable characteristic of wild white clover on thin soils, on fields which are closed for hay late. Dutch white clover was very much inferior to wild white clover. Alsike, although not good, was better relatively at the upland centre. The re-entry of unsown species was more rapid at the upland centre.

Figures indicating the relative contribution of the strains of red clover to the second hay crop are given in Table III.

TABLE II.

Botanical analyses based on productivity estimations of the second harvest year hay crop, 1929. Average of each species sown, irrespective of mixture.*

Centre	*Perennial rye-grass*	*Italian rye-grass*	*Cocksfoot (Station-bred)*	*Cocksfoot (commercial)*	*Timothy*	*Rough-stalked meadow grass*	*Crested dogs-tail*	*Red clover*	*Alsike*	*Wild white clover*	*Dutch white clover*	*Unsown species*
Upland	37	Trace	3	4	8	4	37	13	4	7	1	14
Lowland	35	Trace	7	16	17	5	13	29	1	3	Trace	9
Average	36	Trace	5	10	13	5	25	21	3	5	1	12

*For this reason percentages do not total 100.

TABLE III.

Showing the relative percentage contribution of the red clovers to the second hay crop (1929).

Strain and seed rate in lb. per acre	*Upland centre*	*Lowland centre*	*Average*	*Relative with Mont. red alone at 100*
Montgomery red clover : 6	15	41	28	100
Montgomery : 3 ; English late-flowering red clover 3	19	30	25	89
Montgomery 2 ; English late-flowering red clover 2 ; broad red clover 2	10	24	17	61
English late-flowering red clover 6	3	9	6	21
English late-flowering red clover 2 ; broad red clover 4	3	4	4	14
Average	10	22	16	—

The figures in Table III show that the percentage contribution of the red clovers to the hay is dependent on the amount of Montgomery red clover included in the mixture. Both English late-flowering red clover and broad red clover lack persistence, and as they are earlier to start growth than Montgomery red clover they have suffered relatively more from spring grazing during the first and second years. Furthermore, Montgomery red clover tillers more successfully and, for this reason, it can withstand grazing better. The contribution of the red clovers is much lower at the upland centre because (a) fertility is lower ; (b) winter-spring grazing is more severe and prolonged, and (c) crested dogstail is very aggressive and has an inhibiting effect on the clover. The data are in keeping with Williams's findings after extensive and critical trials over a period of years (3).

Second Harvest Year. Pasture—Upland Centre : July, 1929.

Observation notes were taken at the upland grazed centre in July, 1929.

The reaction of the species and strains as pasture after severe and prolonged grazing was in many respects markedly different from that at the other centres where hay was taken. The plots at the time of visit had been rested for three weeks. Station-bred cocksfoot was outstanding and leafy, and formed a dense sole to the sward. Both strains of cocksfoot were more productive than perennial rye-grass; the commercial cocksfoot, however, was stemmy. The commercial perennial rye-grass did not appear to tiller well. Indigenous perennial rye-grass, when not in competition with cocksfoot, formed a dense sward. Both rough-stalked meadow grass and crested dogstail were fairly good, but it was not possible to discern any results from differences in seed rate per acre. Montgomery red clover was thin, but it was clearly the best of the red clovers. Wild white clover was excellent on all plots where it had been sown. Commercial timothy plants were only occasional, and where found they were unitillered. Mixture 10, a complete commercial mixture containing Dutch white clover and no bottom grasses, formed a very open sward and was very weedy.

The Behaviour of the Species and Strains as Pasture—1928 to 1935 (First to Eighth Harvest Years).

The greater part of the data deals with one upland centre (Centre 3) where hay was taken in the first harvest year, while the plots were grazed in subsequent years. The lowland centre was ploughed in the third harvest year, but aftermath data are available in the second harvest year.

1928—*First Harvest Year Aftermath—Upland Centres.*

Detailed botanical analyses were carried out at the two centres in September of the first harvest year. The data are given in Table IV. As the respective species and strains behaved similarly at both centres, the figures are averaged.

The two strains of perennial rye-grass behaved very similarly, while there was no significant difference between the two strains of cocksfoot on a tiller basis. Light seed rates of indigenous perennial rye-grass, however, were sensitive to competition from heavier seed rates of cocksfoot (Mixtures 5 and 6). On the other hand, relatively light seed rates of cocksfoot suffered in competition with heavier seed rates of perennial rye-grass (Mixtures 1, 2, 7 and 10). Commercial timothy, even when sown at 8 lb. per acre (Mixture 7), is not a strong competitor. Both rough-stalked meadow grass and crested dogstail have established well. It would appear, however, that their contribution at this stage (1st harvest year) is to some extent dependent on seed rate. Rough-stalked meadow grass when sown at the rate of 1 lb. per acre (Mixtures 1 and 3) contributes a lower percentage of tillers than when it is sown at 2 and 3 lb. per acre (Mixtures 5, 7, 8 and 9). Similarly crested dogstail, when Mixtures 2 and 4 (1 lb. per acre) are compared with Mixtures 6, 7, 8 and 9 (2 and 3 lb. per acre). There is no

TABLE IV.

Showing the percentage contribution (tiller estimations) of the species and strains in September of the first harvest year after hay. Average two upland centres.

Species and strain	*Mixtures*										*Average*
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	
Italian rye-grass	2.7	1.0	1.0	3.2	3.0	0.5	2.2	1.0	0.2	0.7	1.5
Perennial rye-grass (indigenous)	—	47.5	—	44.5	32.0	26.5	—	43.5	40.3	—	39.0
Perennial rye-grass (commercial)	43.0	—	49.3	—	—	—	26.3	—	—	42.3	40.2
Cocksfoot (Station-bred)	—	5.5	—	—	—	19.0	5.0	—	—	—	9.8
Cocksfoot (commercial)	6.8	—	—	—	14.5	—	—	—	—	4.5	8.6
Timothy (commercial)	2.0	0.7	—	—	—	—	2.0	—	—	3.8	2.1
Rough-stalked meadow grass	9.3	—	12.7	—	24.0	—	18.8	19.5	14.0	—	16.4
Crested dogstail	—	11.5	—	13.5	—	19.5	17.0	14.0	15.3	—	15.1
Red clover	19.0	17.0	16.5	16.5	17.3	11.8	12.5	7.0	9.3	11.3	13.6
Alsike	—	—	—	—	—	—	—	—	—	Trace	Trace
Wild white clover	3.5	5.5	5.0	4.7	3.5	4.8	7.0	2.5	5.5	—	4.7
Dutch white clover	—	—	—	—	—	—	—	—	—	2.7	2.7
Unsown species	15.7	11.3	15.5	17.6	5.7	17.9	9.2	12.5	15.4	34.7	—

significant difference, however, between the 2 lb. and the 3 lb. per acre seedings of these two species. It is probable that 2 lb. per acre is an ample seed rate for each, as under suitable conditions they are both able to spread very rapidly. Alsike does not contribute to any extent. The separate figures given for wild white clover and the figure for Dutch white clover, represent an average of four replications. All the wild white clover figures, except one (Mixture 8), are higher than the figures for Dutch white clover. In the absence of further replications of the Dutch white clover plots the figures cannot be regarded as highly significant. They do, however, help to confirm previous evidence of a similar nature (4).

1929—*Second Harvest Year Aftermath—Lowland Centre.*

The statement in Table V gives the position at the lowland centre in the autumn of the second harvest year. The figures are based on tiller estimations and represent the average for each species and strain.

On a tiller basis the indigenous perennial rye-grass (Mixtures 2, 4, 5, 6, 8, 9) is appreciably better than the commercial strain (Mixtures 1, 3, 7, 10). The high figures for the two strains of perennial rye-grass show that they provide a long grazing season and in the second year on somewhat heavy lowland soils after hay they are aggressive in relation to cocksfoot even in the aftermath. The cocksfoot strains are late to establish and as they make slow growth they suffer in competition with heavier seed rates of perennial rye-grass. Timothy makes a relatively poor contribution. Rough-stalked meadow grass makes a very high contribution and yet at this centre it contributed very little to the second hay crop. Rough-stalked meadow grass, however, is perhaps essentially a pasture grass and in this respect it is extremely valuable for filling in bare spaces. It is not a uniformly strong competitor in the hay; sometimes, however, when it establishes quickly from sown seed, it is quite productive in the first hay crop, and occasionally in the second also.

Crested dogstail was more productive in the second hay crop than rough-stalked meadow grass. In the aftermath, however, as the figures show, it is clearly superseded by rough-stalked meadow grass. Usually crested dogstail is more aggressive on relatively infertile soils, whereas rough-stalked meadow grass prefers fertile soils well supplied with moisture. As hay, crested dogstail runs to head very soon, and this may to some extent account for its higher productivity in the second hay crop at this centre. The figures for wild white clover in comparison with Dutch white clover show

TABLE V.

Percentage Tiller Estimations. (September, 1928, 2nd harvest year.)

Lowlands. All mixtures averaged.*

Italian rye-grass	*Perennial rye-grass*		*Cocksfoot*		*Timothy*	*Rough-stalked meadow grass*	*Crested dogs-tail*	*Red clover*	*Wild white clover*	*Dutch white clover*	*Alsike*	*Unsown spp.*
	(commercial)	*(indigenous)*	*(commercial)*	*(Station-bred)*	*(commercial*							
Trace	42	50	5	6	2	34	11	1	9	2	Trace	12

*As all mixtures are here averaged, percentages do not total 100.

that usually even on good soils wild white clover is slow to make appreciable unsown appearance. Alsike has almost completely died out. The red clovers, including Montgomery red clover, have died back considerably after the second hay crop and the figures indicate that they will contribute very little to the third hay crop. The average figure for unsown species for all the mixtures is 12, the figure for Mixture 10 (all commercial), however, is much higher even allowing for a considerable unsown entry of rough-stalked meadow grass. Yorkshire fog and bent are the main weeds. Mixture 10 gave poor results even in comparison with the other commercial mixtures which contained also wild white clover and rough-stalked meadow grass. Rough-stalked meadow grass was not included in Mixture 10, the complete commercial mixture.

The contribution of the various species and strains as pasture at one upland centre (Centre III) in successive years (excluding 1929 and 1935) is shown in Table VI. In regard to cocksfoot and perennial rye-grass, mixtures containing the same strains are averaged for each year. The figures for crested dogstail and rough-stalked meadow grass represent averages for all the plots, irrespective of whether these species were sown.

The data in Table VI represent percentage tiller estimations. Indigenous perennial rye-grass has shown to advantage in comparison with commercial perennial rye-grass in spite of competition on some plots with Station-bred cocksfoot, which latter strain was highly persistent and at certain periods of the year very aggressive. The figures are an average of a number of plots. When perennial rye-grass and cocksfoot were sown in the same mixture the indigenous strains were generally used together, and the commercial strains similarly, except on one plot (Mixture 7) where Station-bred cocksfoot and commercial rye-grass were included in the same mixture. Commercial cocksfoot, even when sown at a heavy seed rate per acre, was not a strong competitor after the third year. Station-bred cocksfoot was slow to become well established, but from the third to the sixth years it was highly aggressive. It appeared to reach its peak of aggressiveness in the fourth and fifth years, after which it seemed gradually to lose ground. Under the system of management adopted on this field it tended to have an adverse effect on perennial rye-grass. The plot was grazed hard right through the winter and spring, after which time it was grazed leniently until September to October with a view to providing winter keep. Most of the plots were grazed very severely whenever stock were on the field, and sheep in particular spent most of their time on them, neglecting about two-thirds of the field, which was almost completely dominated by *Agrostis*. A com-

TABLE VI.

Showing the percentage contribution of the various species and strains as pasture in various harvest years. One upland centre, sown 1927.

	Species and strains										
	Perennial rye-grass (commercial)	*Perennial rye-grass (indigenous)*	*Cocksfoot (commercial)*	*Cocksfoot (Station-bred)*	*Timothy*	*Rough-stalked meadow grass*	*Crested dogstail*	*Red clover*	*Wild white clover*	*White Dutch clover*	*Unsown species*
Mixtures averaged	1.3.7.10.	2.4.5.6.8.9.	1.5.10	2.6.7.	1.2.8.10.	1.3.5.7.8.9.	2.4.6.7.8.9.	1-10	1-9	10	1-10
1928	38	36	10	13	1	15	13	15	5	3	23
1930	32	38	6	30	1	8	8	Trace	20	5	26
1931	17	31	2	48	Trace	23	11	,,	18	9	22
1932	13	40	Trace	60	,,	22	6	—	12	6	32
1934	17	44	1	27	,,	2	4	—	17	5	38
1935	14	28	1	21	,,	5	17	—	28	14	28
Average	22	36	3	33	Trace	13	10	3	17	7	28

parison of droppings on the plots in relation to most of the remainder of the field would indicate that the plots were very well manured. When the seeds were sown the field as a whole was regarded as being very low in fertility. It is probable, therefore, that the fertility built up by sheep droppings and urine may largely account for the persistency of these strains. The figures for commercial perennial rye-grass are higher than would be expected under these conditions following upon severe defoliation over a period of years.

The amount of commercial timothy present was negligible each year, and indicates that on relatively thin soils it is a poor competitor, at a light seed rate per acre, in comparison with cocksfoot and perennial rye-grass. Wild white clover contributed in appreciable quantity on the plots on which it was sown.

Wild white clover (unsown) did not seem to gain ground on the plot which was sown with Dutch white clover (a complete commercial plot), even in the seventh and eighth years. This plot was also very weedy and relatively unpalatable. The low figure for indigenous perennial rye-grass in 1935 is due, in part, to a high content of wild white clover and crested dogstail in the same year.

In Table VII comparisons are made between the relative effect of heavy seed rates per acre of Station-bred and Danish cocksfoot on indigenous perennial rye-grass when the latter is sown at a light seed rate per acre (Mixtures 5 and 6). The figures each year were taken during the summer months when grazing was lenient and therefore at a time when cocksfoot tended to make rapid growth. The cocksfoot, however, was never out of hand.

TABLE VII.

Showing the effect of heavy seedings of Danish and Station-bred cocksfoot respectively on indigenous perennial rye-grass at a light seed rate per acre. One upland centre.

	Percentage tiller estimations of perennial rye-grass	
	With Danish cocksfoot	*With Station-bred cocksfoot*
1928	27	16
1930	45	9
1931	33	9
1932	46	2
1934	54	16
1935	32	21
Average	39	12

Whereas after the third year the amount of Danish cocksfoot was negligible, Station-bred cocksfoot from the third to the sixth harvest years was very aggressive. This competitive effect on rye-grass is well shown in the comparative figures. In 1934 and 1935, Station-bred cocksfoot was not so vigorous. During these years the rye-grass recovered very well. It is important to note, however, that although Station-bred cocksfoot dominated the sward, its herbage was always relatively short, and therefore the rye-grass was not completely smothered. The figures indicate that provided the rye-grass is not totally killed, it is capable, through high tillering, of remarkable subsequent recovery.

In Table VIII comparisons are made between light and heavy seed rates of indigenous perennial rye-grass in the mixtures (Mixtures 5 and 8). The mixture containing the light seed rate per acre of rye-grass also contained Danish cocksfoot (20 lb. per acre). The mixture with the heavy seed rate of rye-grass also contained crested dogstail (1 lb. per acre). The other ingredients in each mixture were precisely similar.

TABLE VIII.

To compare light and heavy seed rates of indigenous perennial rye-grass in mixtures.

	Light seed rate (5 lb. per acre)	*Heavy seed rate (20 lb. per acre)*
1928	27	45
1930	45	48
1931	33	45
1932	46	60
1934	54	56
1935	32	28
Average	39	47

The relative contribution due to the different seed rates of indigenous perennial rye-grass per acre (5 lb. and 20 lb.), although appreciable, is not so great as would be expected.

In the second and later years the tendency to level up irrespective of seed rate is often shown also in regard to wild white clover, crested dogstail and rough-stalked meadow grass on soils that suit them. They are also capable of making appreciable unsown appearance. In this trial there is a difference between the contribution of Station-bred cocksfoot from an 8 lb. seeding and a 20 lb. seeding, but the difference is certainly not in proportion to the difference in seed rate. In fact, the difference is relatively slight, and perhaps may not be due to seed rate, but to different degrees of competition. A comparison of the commercial and indigenous rye-grass plots in this trial indicates a definite superiority in favour of the indigenous strain, and on these plots there has been very little opportunity for reseeding. It is suggested, therefore, that the indigenous rye-grass has spread in relation to the degree of persistency and the competitive ability of the species and strains associated with it. In the compounding of seeds mixtures this might well be a very important factor. On soils that suit it and given conditions to suit rapid tillering, light seedings of indigenous strains of rye-grass may be all that are needed in conjunction with similar or perhaps heavier seedings of commercial strains. The other species may act as a nurse crop to the indigenous rye-grass for a few years, while after they have died, the indigenous rye-grass, when given opportunities to tiller well and in conjunction with wild white clover, may hold the sward successfully for several years.

In any event the evidence indicates very marked vitality in indigenous rye-grass to tide over adverse periods and to spread by means of tillers where and when more favourable conditions prevail. These observations have been confirmed to a remarkable degree by the results from subsequent trials consisting of mixtures made up of a blend of strains within the chief contributing species.

The following statement, based on a " ground cover " analysis carried out in June, 1936, the ninth harvest year, indicates the condition of the plots at that time. All the plots which contained indigenous perennial rye-grass, but no Station-bred cocksfoot, have been averaged (Mixtures 4, 5, 8, 9). Similarly in regard to commercial perennial rye-grass, Mixtures 1 and 3 have been averaged. Only one mixture contained Dutch white clover (Mixture 10) ; the figures in this case, therefore, are an average of two replications only.

Percentage ground covered in the ninth harvest year—10 readings per plot.

	Perennial rye-grass	*White clover*	*Weeds*	*Moss*
Indigenous plots sown with wild white clover	26.0	30.0	30.0	4.0
Commercial plots sown with wild white clover	11.0	37.0	39.0	4.0
Commercial plot sown without wild white clover	3.0	9.5	70.0	9.5

The complete commercial plots (Mixture 10) sown originally with Dutch white clover, but no wild white clover, were still low in unsown wild white clover content, while weeds covered 70 per cent of the ground. All the other plots were rich in wild white clover irrespective of the initial amount of this strain which was sown. This emphasises the need to sow this valuable strain even if only at a low seed rate per acre. Commercial perennial rye-grass persisted better on the plots sown with wild white clover than on the plots sown without wild white clover. The plots sown without wild white clover were never very closely grazed, especially during the summer, and *Agrostis* spp. and Yorkshire fog were allowed to make headway. This poor grazing intensity to some extent, no doubt, accounts for the low content of perennial rye-grass and wild white clover in the plots mentioned. The harder grazing of the plus wild white clover plots would appear to have been a valuable factor because (a) fixation of nitrogen by wild white clover helped the associated grasses, and (b) more intensive stock concentration helped fertility. The figures, however, show that indigenous perennial rye-grass has persisted far better than commercial perennial rye-grass. Station-bred cocksfoot still covered an average of 14 per cent of the ground.

Summary.

(1) Montgomery red clover was more productive and also more persistent than either broad red clover or English late-flowering red clover.

(2) Indigenous and/or Station-bred strains of both cocksfoot and perennial rye-grass persisted better than commercial strains. Commercial cocksfoot, in particular, could not withstand the severe upland grazing imposed upon it. Station-bred cocksfoot was an aggressor relative to perennial rye-grass from the third to about the sixth harvest year.

(3) Rough-stalked meadow grass, as a sown species, contributed well to the first hay crop on the lowlands. It was not such a high contributor as hay in the second year. On a tiller basis it would appear to be at its best in the early autumn. Later in the year, especially on the uplands, it presented a reddish appearance.

(4) Crested dogstail contributed well to the upland second hay crop, but it was stemmy.

(5) After the third year differences due to the seed rate of wild white clover, rough-stalked meadow grass and crested dogstail were not significant. The upland plots which were not sown with wild white clover, however, never contained a high percentage of this strain as an unsown (= volunteer) contributor.

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References.

1. Davies, William (1931). Methods of pasture analyses and fodder sampling. *Welsh Plant Breeding Station Report.* No. 1.
2. Thomas, M. T. (1934). Competition in seeds mixtures at high elevations (850 ft.) at Moelglomen, Talybont, Cardiganshire. *Ann. App. Biol.* 21. No. 4. 553-65.
3. Williams, R. D. (1927). Red clover investigations, 1919-26. *Welsh Plant Breeding Station Bulletin,* Series H. No. 7.
4. ———————— (1932). White clover trials, 1926-31. *J. Minist. Agric.* 39. pp. 708-18.

THE YIELD AND OTHER CHARACTERISTICS OF [redacted] AND CLOVERS WHEN SOWN IN SIMPLE MIXTURES ON AN EXPOSED HILL AT AN ELEVATION OF 1,300 FEET.

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Description of Area.

The Exposure Area (Block 24) on which were laid out the series of trials to be discussed below, is about two acres in size and has been fenced off from the main body of the hill. The site was chosen as representing extreme exposed conditions under which critical trials could be conducted along standardized Station lines. The Exposure Area stands at an elevation of about 1,300 ft. and has a slight slope facing north-east. The soil over the greater part of the area is a light shaly loam, nowhere of greater depth than 6-7 inches. In places the shale comes within a few inches of the surface, while in others there is a peaty layer overlying the mineral subsoil, but the peat is seldom of any depth.

Part of the area had been at some time (probably during the early part of the 19th century) planted with conifers and other trees; these had been felled about 1908, and the area run once more as part of the open hill grazings until 1933. The vegetation over the whole block in 1933 was composed chiefly of sheep's fescue, *Nardus* and *Molinia* with lesser amounts of *Agrostis, Sieglingia* and *Anthoxanthum.* Among the non-gramineous elements *Vaccinium, Carex, Potentilla, Luzula* and *Galium saxatile* were prominent, while cushions of *Polytrichum* moss (*P. commune*) were abundant. There were no legumes, and the sward was dense and matted, an usual feature of unimproved hill lands.

About one-half of the area (that free of tree stumps) was ploughed in 1934, and winter oats were sown. The oats failed and this part of the field was harrowed up and resown with rape which was fed off with sheep. The whole area (including that previously not ploughed and from which the tree stumps had now been removed) was ploughed up in the spring of 1936. The seeds mixture trials described hereunder were sown on 12th May, 1936.

The soil has a high lime requirement, and a low pH value (about 3.8—4.0 using the standard Quinhydrode Electrode method). Lime was not applied previous to sowing the seeds, though portions of the area have subsequently been limed on an experimental basis. The whole area received 11 cwt. per acre of basic slag (total phosphate 32 per cent), and 1 cwt. per acre of nitro-chalk (N. 15½ per cent), on 11th May, 1936, just prior to sowing. That part which had previously been ploughed in 1934, and ploughed a second time in 1936, had received basic slag (6 cwt. per acre) and nitro-chalk (1 cwt. per acre) given as dressings to the previous oat and root crops. The remainder (ploughed for the first time in 1936) had received none of this previous manuring.

Details of the Experiments.

There were four separate, though closely related, series of trials as follows :—

E.192. A grass and clover strain trial involving an aggregate of sixty-one strains belonging to nineteen different species. Plots in triplicate; a total number of 181 plots each of 1/200th acre.

E.193. Rate of seeding trial employing a simple mixture of rye-grass, dogstail and white clover. Seven seeds mixtures in 1/200th acre plots, and in quadruplicate, with a total of 28 plots.

E.194. Seeds mixture trial to test the influence of competition exerted upon the sown species when cocksfoot and Yorkshire fog are added to a basal mixture of rye-grass, dogstail, bent and wild white clover. Seven seeds mixtures in 1/200th acre plots replicated eight times, giving a total of 56 plots.

E.195. To test a series of ultra-simple mixtures on peaty soil; 8 mixtures (no replicates), mainly in 1/20th acre plots.

Heavy showers fell during the night prior to sowing seeds, and in consequence the top soil was damp. Previously the weather had been dry for some days. The seeds were sown on the harrowed surface, and after sowing the whole area was rolled, using a heavy Cambridge roller. Covering was fairly good, although not complete, some of the larger seeds remaining unburied on the surface. Sowing conditions on the whole were satisfactory, but not ideal.

E.192 strain trial.

Table I shows a list of the species and strains under test in this trial. The seed rate used for all the grasses was 40 lb. per acre, with the exception of smooth-stalked meadow grass, which was sown at 50 lb. per acre.* Red, alsike and subterranean clovers were each sown at the rate of 10 lb. per acre; white clover at 4 lb. per acre, and *Lotus major* at 15 lb. per acre. Wild white clover at 2 lb. per acre was sown with each of the grasses, while rye-grass (S.23) at 20 lb. per acre was sown with each of the clovers, including *Lotus major*. Each plot therefore was sown with an ultra-simple mixture, consisting in every case of one grass and one clover.

The weather subsequent to sowing remained fairly dry, and there was no growth on the plots until towards the end of June. The month of May was dry (about 2½ inches total rainfall), but June was wet, with about 5½ inches of rainfall, and fairly warm, making for good conditions for seed establishment.

Results.

The Seeding Year (1936) : *Seeding Establishment and Growth.*

Notes taken six weeks after sowing (28/6/36) indicate that timothy and rough-stalked meadow grass established themselves more rapidly than any other species, and during this period both species made remarkably good growth. Meadow fescue, tall fescue, dogstail, smooth-stalked meadow grass and the clovers

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*An adjusted seed rate of 60 lb. per acre was made in the case of S.24 perennial rye-grass to compensate for low germination of the seed.

TABLE I.

Giving details of the various strains and species under test. E.192, Exposure Area, Cahn Hill Improvement Scheme, sown 1936.

Species	*Number of strains under test*	*Particulars of strains tested*
Perennial rye-grass	4	Aberystwyth bred strains: S.24 (hay); S.101 (pasture); S.23 (pasture); and commercial.
Cocksfoot	7	Aberystwyth S.37 (hay); S.26 (pasture); S.142 (pasture); S.143 (pasture); S.146 (pasture); S.29 (extreme-pasture) and commercial (Danish).
Timothy	5	Aberystwyth S.51 (hay); S.48 (pasture); S.50 (pasture); S.49 (pasture) and commercial.
Meadow fescue	3	Aberystwyth S.53; Bf. 175 and commercial.
Crested dogstail	1	Commercial only.
Rough-stalked meadow grass	1	Commercial only.
Meadow foxtail	2	Aberystwyth S.55 (pasture) and commercial.
Fine-leaved fescues	4	Aberystwyth S.59 (red fescue); S.58 (sheep's fescue); commercial hard fescue; commercial red fescue.
Tall fescue	2	Aberystwyth S.170 and commercial.
Smooth-stalked meadow grass	5	Aberystwyth S.63; S.62; Bp. 194; Bp 176 and commercial.
Yorkshire fog	3	Aberystwyth Bs. 477; Bs. 1077 and commercial.
Bent (*Agrostis tenuis*)	1	New Zealand brown top.
Phalaris sp.	3	Aberystwyth Bs. 387 (hybrid); Bs. 1123 (hybrid) and commercial (Australian *Ph. tuberosa*).
Sweet vernal grass	2	Aberystwyth Bs. 15; commercial.
Red clover	7	Aberystwyth S.148 (Montgomery); S.149 (late X wild); S.140 (wild); commercial broad; late; Montgomery and wild.
Alsike clover	1	Commercial only.
White clover	4	Aberystwyth S.126 (wild); S.118 (large-leaved); S.134 (mountain type); commercial wild.
Subterranean clover	4	Australian Dwalganup (early); Bacchus Marsh (second early); Mt. Barker (mid.); Bass (late).
Lotus major	2	Aberystwyth S.121; commercial.
Total	61	strains, and representing 19 different grasses and clovers.

made a very poor start, and had made practically no growth whatever in this first six weeks. Apart from the behaviour of individual species, the most marked feature on the whole experimental area at this period was the wide difference shown in the rate of establishment of plots on the once-ploughed portion, when compared to those on the twice-ploughed area. Growth was far more rapid on the latter half of the field, and it almost seemed at this early stage that the plots on the once-ploughed portion would show a high percentage of failures. This initial contrast had been largely deleted, however, by the end of July, 1936 (ten weeks after sowing), the recovery hastened, no doubt, by the excessive rainfall (over 7¾ inches) which fell in that month.

Careful notes were made on all the plots on 28th July, 1936—ten weeks after sowing—and marks alloted relative to establishment and yield on each plot. These data are summarized in Table II. Timothy (hay types) had made the most growth of all the species, followed by rough-stalked meadow grass as second best. Rye-grass, Yorkshire fog and cocksfoot had also made fairly rapid growth, whereas bent, sweet vernal and crested dogstail were markedly less productive, though appreciably more so than meadow, tall and fine-leaved fescues, or meadow foxtail, smooth-stalked meadow grass and *Phalaris.* None of this last named group, except perhaps meadow fescue, was making any appreciable contribution to keep at this time. Red clover strains had established themselves satisfactorily, but were not as productive as the best of the grasses. Alsike clover had made more growth than any of the red clovers; white clover was poorer than the red, and was about equal to the growth made by subterranean clover. *Lotus major* (Aberystwyth S.121) had established itself well, and was making quite as much growth as red clover, but the commercial strain was markedly poorer. Having regard to all the species there were no more than slight differences relative to the individual strains. In the grasses the pasture strains tended to be slower in initial growth when compared with the hay strains. In red clover the differences were slightly in favour of the late-flowering and Montgomery types. In white clover difference between strains was slight—the pedigree types were appreciably the slower in establishment, " mountain " type (S.134) in particular.

Counts of Plants in Seeding Year. In October, 1936, some five months after sowing, plant counts were made on the plots sown with red clover (and rye-grass S.23), and from these data the percentage establishment of rye-grass and of the red clovers was

TABLE II.

To show the relative establishment and growth of the several grasses and clovers at ten weeks after sowing. E.192, Exposure Area, 28/7/36. (Commercial timothy = 100.)

Species	*Establishment*	*Growth*
Timothy (commercial)	100	100
,, (pedigree : hay S.51)	100	100
,, (pedigree : pasture S.48, S.50, S.49)	97	65
Average all strains	98	78
Perennial rye-grass (commercial)	97	57
,, (pedigree : hay S.24)	100	60
,, (pedigree : pasture S.100 and S.23)	97	53
Average all strains	96	55
Cocksfoot (commercial)	87	57
,, (pedigree : hay S.37)	87	60
,, (pedigree : pasture, 5 strains)	77	54
Average all strains	79	55
Rough-stalked meadow grass (commercial)	100	87
Yorkshire fog (3 strains)	95	74
Sweet vernal (2 strains)	80	26
New Zealand bent (1 strain)	70	33
Crested dogstail (1 strain)	83	30
Fine-leaved fescue (4 strains)	38	2
Meadow fescue (3 strains)	42	17
Tall fescue (2 strains)	25	1
Meadow foxtail (2 strains)	33	3
Smooth-stalked meadow grass (5 strains)	35	3
Phalaris varieties (3 strains)	28	4
Red clover (7 strains)	86	22
Alsike clover (1 strain)	100	37
White clover (4 strains)	53	14
Lotus major (2 strains)	53	14
Subterranean clover (4 strains)	68	14

calculated. These readings were repeated in May, and again in October of the first harvest year (Table III).

On the average of all strains the percentage establishment of red clover was 29.4 per cent (range 22.6 per cent in broad red clover to 36.0 per cent in pedigree wild S.140), while the figure for S.23 rye-grass averaged 45.4 per cent. These figures are slightly higher than those obtained in certain lowland trials by the Station (Davies (1) and Davis (2)). We are dealing here with frequency, and not with productivity, as such. The higher rate of plant establishment under the exposed hill conditions, i.e., probably a reflection of the less rapid growth of the sward as a whole, and

TABLE III.

To show the percentage establishment of seven strains of red clover at three sequential dates in the seeding and first harvest years when sown in a simple mixture. The percentage overwintered is also given, and similar data are shown for perennial rye-grass (S.23). E. 192, Exposure Area, 1936-37.

Strains	*Seeding year,* 1936 *October*	*1st harvest year*		*Percentage over-wintered (Oct. to May)*
		May	*October*	
Wild red (pedigree : S.140)	36.0	25.8	25.4	71
Wild red (commercial)	31.3	19.7	12.1	63 } 63 = wild and wild crosses
Wild X late (pedigree : S.149)	28.6	15.3	15.4	54
Mont. X Cornish Marl (S.148)	28.7	12.4	18.2	43 } 35 = Montgomery types
Montgomery (commercial)	34.1	8.9	8.1	26
Late-flowering (Essex)	24.6	3.4	1.3	13
Broad red (Essex)	22.6	0.7	1.8	3 } 8 = ordinary commercial types
Average of all strains	29.4	12.3	11.7	
Perennial rye-grass (S.23)	45.4	38.9	35.0	85

in consequence the less intense competition between individual plants of the sown species. Added to this is the fact that newly-formed swards on hills such as these do not have to contend with any appreciable competition from weeds and other unsown species. The chief "weed" species—almost the only ones appearing in noticeable quantities—in the seeding year were bent and sheep's fescue. There was also a small amount of *Poa annua* and moss. Apart from the bent which appeared as isolated tussocks all over the area, none of these "weeds" was sufficiently aggressive materially to affect the initial establishment of the sown grasses and clovers.

Grazing in the Seeding Year. The experimental area was grazed for the first time after reseeding on 17th October, 1936, when it provided keep for 24-25 sheep for a period of twelve days, and contributed a total of 295 sheep days, equivalent to about 150 sheep days per acre. There was no further grazing on the area until June, 1937.

The seeding year was therefore a period of meagre total growth. The swards on most plots were either thin and open, or if dense at the base, the total growth was still small. None of the clovers made appreciable growth, whereas the swards in general gave every indication of lack of readily available plant foods. There has been a marked improvement in this respect in the subsequent harvest years (particularly from the second harvest year onwards), and this improvement has been associated with the spread of wild white clover and of bent (unsown) on most plots. The tendency for older leys to be more productive than new leys has been noted in connexion with moorland reclamation work in Scandinavia, and this presents a point of some considerable interest connected with grassland improvement on lowland as well as on upland. It may also be possible that new leys on certain classes of "difficult" lowlands, such as those mid-England clays, do not normally attain to their maximum productivity until later than the first harvest year. This raises a series of important practical as well as technical problems.

The First Harvest Year.

(1) *Late Winter and Early Spring,* 1937. Compared with lowland conditions spring growth in the first harvest year on the trial area commenced very late. In mid-March, 1937, the only plots showing even the minimum of green herbage were those sown with pedigree cocksfoot (S.29), sweet vernal, Yorkshire fog, bent, pedigree smooth-stalked meadow grass (Bp 194), pedigree timothy (S.50), and rough-stalked meadow grass. The clumps of "native" bent which had made an unsown indigenous appearance in the seeding year appeared winter-green and gave some keep.

Even by the middle of April few of the sown species were making any real growth. Commercial red fescue, and the pedigree sweet vernal (Bs 15), had made the most growth, while rough-stalked meadow grass and pasture timothy (S.48 and S.50) were just commencing growth. All the rye-grass lots were poor and had not begun to grow, and the same applied to all the clovers, meadow fescue, tall fescue, dogstail, *Phalaris*, and sheep's fescue. None of the strains of cocksfoot showed up well, though the pasture type, S.29, was still the best, and Danish cocksfoot by far the poorest of them. Yorkshire fog was starting growth mainly from the nodes of old decumbent stems. By the latter end of the month (April 30th) growth was commencing on most plots, although the total keep offering was still very small. Marks allotted for comparative growth, and for density of cover, are summarized in Table IV. The data show that bent and sweet vernal (the pedigree strain (Bs 15) especially) had made the most growth, followed by timothy, cocksfoot and Yorkshire fog. Rye-grass, the fescues, the meadow grasses, foxtail, *Phalaris* and the clovers were all poor.

TABLE IV.

To show the comparative growth and the density of swards contributed by the several species in the spring of the first harvest year (New Zealand bent = 100). E.192, Exposure Area, 30/4/37.

Species	*Growth*	*Ground cover*	*Range in growth*
Timothy (5 strains)	63	82	Most growth commercial (85), least growth S.49 pasture (40).
Rye-grass (4 strains)	25	35	Most growth S.23 pasture (40) ; least growth commercial (10).
Cocksfoot (7 strains)	60	51	Most growth S.142 pasture (85) ; least growth commercial (20).
Rough-stalked meadow grass (1 strain)	25	95	
Yorkshire fog (3 strains)	49	73	Most growth Bs. 1077 (55) ; least growth Bs. 477 (40).
Sweet vernal (2 strains)	85	70	Most growth pedigree (100) ; least growth commercial (70).
N.Z. bent (1 strain)	100	100	
Crested dogstail (1 strain)	10	30	
Fine-leaved fescues (4 strains)	24	45	Most growth commercial red fescue (35) ; least growth commercial hard fescue (17).
Meadow fescue (3 strains)	6	24	Most growth S.53 pasture (10) ; least growth commercial and Bf. 175 (each 5).
Tall fescue (2 strains)	6	10	Most growth S.170 hay (7) ; least growth commercial (6).
Meadow foxtail (2 strains)	20	30	Most growth S.55 pasture (30) ; least growth commercial (10).
Smooth-stalked meadow grass (5 strains)	21	29	Differences between strains small (growth range 15 to 25).
Phalaris vars. (3 strains)	3	2	All strains similarly poor.
Legumes (clovers and *Lotus major*)	Neg.	Neg.	Growth of all the clovers practically nil.

The bent (sown) was a dense mat of leafage, but this had been badly "tip burned", so that the plots presented a blackened appearance.

It was noticeable that the plants of indigenous (unsown) bent remained green, but were making active growth at this time.

In later harvest years, however, this comparative winter greenness on the part of the unsown indigenous bent has not proved to be so marked. A prominent feature on many plots in the early spring of the first harvest year was a conspicuous "heaving" of the individual plants. These appeared to be "sitting" on little raised hummocks of soil one-half to one inch above the general level of the soil. Often the roots of these plants were partially exposed and lying on the surface.

(2) *Summer Period (June to August,* 1937). The field was grazed by thirty-four sheep, together with thirty-nine lambs for ten days in June (2nd to 12th). With the exception of the plots sown with N.Z. bent (which was not badly "rusted") sweet vernal grass and the fine-leaved fescues, all herbage was readily eaten and there were no striking differences in palatability.

Notes were made during the summer as to relative growth, and botanical analyses of the swards were made in July and early August relative to a large number of the plots. These data are brought together in Table V.

Notes on the Species and Strains.

It will be convenient to discuss the species in relation to the character of the swards that were produced in the first harvest year. They are therefore dealt with in groups as follows :—

(*a*) *Good productive swards*—timothy, cocksfoot, fog, sweet vernal and bent.

(*b*) *Short dense swards*—perennial rye-grass, rough-stalked meadow grass, crested dogstail, fine-leaved fescue.

(*c*) *Swards of the lowest productivity*—meadow fescue, tall fescue, meadow foxtail, *Phalaris* and smooth-stalked meadow grass.

(*a*) Good productive swards.

Timothy. One of the outstanding species in the trial, it made good recovery after grazing and was at all times highly palatable. The hay types (commercial and S.51) were the most productive, followed closely by the pasture-hay type (S.48). The extreme pasture types (S.50 and S.49) were less productive, S.50 making a dense, short sward, while S.49 was more open and less vigorous.

Cocksfoot. Cocksfoot proved to be the most productive grass during the first harvest year. The pedigree strains as a whole

TABLE V.

To show (a) the average comparative growth* at a series of dates during the first harvest year, and (b) the botanical composition of the swards (July to August of that year). E.192, Exposure Area, 1937.

Species	*Number of strains averaged*	*Average growth**	*Percentage area*			
			Sown grass	*Sown white clover*	*Unsown spp. including bent and fog*	*Bare ground and moss*
(*a*) *Good productive swards*						
Timothy	5	57	48	14	23	15
Cocksfoot	7	86	48	6	22	24
Yorkshire fog	3	75	75	5	2	18
Sweet vernal	2	65	60	6	10	24
New Zealand bent	1	70	77	8	8	7
Average	18	71	62	8	13	17
(*b*) *Short dense swards*						
Rye-grass	4	32	42	15	13	30
Rough-stalked meadow grass	1	23	33	32	27	8
Crested dogstail	1	30	40	20	24	16
Fine-leaved fescues	4	20	62	14	16	8
Average	10	26	44	20	20	16
(*c*) *Swards of low productivity*						
Meadow fescue	3	12	27	14	25	34
Tall fescue	2	3	11	7	44	38
Meadow foxtail	2	15	4	22	50	24
Smooth-stalked meadow grass	5	10	38	10	34	21
Phalaris spp.	3	3	4	28	48	20
Average	15	9	17	16	39	27

*Cocksfoot (S.146), the mop type, is placed at 100. This is not however shown separately in the table, but is included in the average figure given for cocksfoot as a whole.

gave appreciably more growth than Danish, but the difference between the several bred strains was no more than nominal. The mop types were the best, while the intermediate forms (S.26 and S.142) were almost as good. The extreme narrow-leaved type (S.29) did remarkably well, and at some stages was the best cocksfoot in the trial. Under lowland conditions S.29 is less productive than the S.26 and mop types, but under these extreme hill conditions it has, on the average, contributed practically as much keep as the best of the leafy strains. The pedigree hay cocksfoot (S.37) was less productive than the leafy pasture cocksfoots, whereas Danish (commercial) was only about half as productive. It is of general interest, however, to record that during June, 1937, when rabbits gained entry into the trial field, Danish cocksfoot plots were the very first of all plots to be grazed by the rabbits. There was less white clover in the cocksfoot plots than in those sown with any other species except Yorkshire fog. This is a direct reflection of relative aggressiveness.

Yorkshire fog. Fog established itself rapidly and maintained a dense cover which proved adverse to the spread of wild white clover and in this respect fog has been more aggressive than any other single species. This grass recovered rapidly after grazing, but it was never as palatable to sheep as many of the other grasses. There were only minor differences between the strains of fog, either in yield or palatability. The low cost of seed and the readiness with which fog will establish itself and grow make it a species of value under hill conditions. Because of its aggressive nature in the sward it is not a grass that can, however, be used without careful discrimination in otherwise highly palatable leys. If employed in a mixture for such leys, the grazing management will need to be such that the fog is periodically grazed off cleanly. The greatest use of fog in connexion with hill reclamation work seems to be in ultra-simple "pioneer' mixtures, composed of say fog, ribgrass and white clover which are designed to be grazed to death as a means for drawing stock on to land in the first phase of hill reclamation. Fog might with advantage be used alone, or in a simple mixture, for the surface seeding (without) cultivations) of wet moorland such as many of the areas now in *Molinia* and cotton grass.

Sweet Vernal grass. Vernal established well and made good growth, but was at no time relished by the sheep. The grass had produced a full crop of inflorescences in May and these had to be scythed off. The commercial strain had produced a second crop of such inflorescences by August. The bred strain always appeared to be the more leafy, but the commercial strain was rather more productive during the first harvest year. White clover was not able to spread in the vernal plots, the clover content being about equal to that of plots sown with cocksfoot.

Bent. More productive than vernal, but less productive than either cocksfoot or fog. It made a dense, fairly weed-free, sward in which wild white clover did not spread in the first year. The plots were of low relative palatability, partly because of a severe rust attack in early summer. A point of practical interest is that wherever bent has been sown in the present series of trials the establishment and growth has been excellent. One of the difficulties usually associated with the use of bent in seeds mixtures is the paucity of established plants resulting from such sowings. Here under exposed hill conditions where sward competition in the initial seedling stages is never so severe as on the lowlands, bent has established satisfactorily and once established has become the aggressor in the pasture.

(*b*) Short Dense Swards.

Perennial rye-grass. Under lowland conditions rye-grass grows rapidly from seed and makes maximum growth in the first year. Under exposed hill conditions rye-grass has made only short dense growth. At all times the pasture strains have outyielded the commercial and hay types. Both S.23 and S.101 have proved somewhat similar in growth and density. Both were superior to the bred hay type (S.24), which in turn was more productive and more dense than the ordinary commercial strain. The pasture strains had a ground cover (1937) of about 50 per cent, compared with S.24 about 40 per cent, and the commercial strain 30 per cent. The relative yields were of a similar order (bred pasture 40,* bred hay 30* and commercial 20*).

Rough-stalked meadow grass. Lower in yield than rye-grass, but forming a denser sward with a higher proportion of white clover than any other species. The rapidity of establishment and growth of rough-stalked meadow grass during the seeding year has been remarked upon, but in the first harvest year it was outyielded by crested dogstail (Thomas (4)).

Crested dogstail. Not so dense a sward as that of rough-stalked meadow grass and lower in content of white clover. The contribution to yield is, however, greater than rough-stalked meadow grass.

Fine-leaved fescues. All the fine-leaved fescues produced short dense cover with a relatively low content of white clover, and a lower aggregate yield than either dogstail or rough-stalked meadow grass. In the first harvest year commercial red fescue gave the highest total yield among the strains, whereas hard fescue gave the lowest yield. The two bred strains, S.59 (red fescue) and S.58 (sheep's fescue) were similar to each other, both with regard to yield and density.

(*c*) Swards of Low Productivity.

Meadow fescue made extremely poor growth during the year, having regard to the fact that it had become moderately well established. The difference between strains was relatively narrow, although the advantage in this respect was definitely with the bred strains, and in particular, S.53.

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*Compared with mop cocksfoot S.146 = 100 for the same period.

Tall fescue did not " take " well, and the growth was very poor. There was no significant difference between the pedigree and commercial strains.

Meadow foxtail was altogether a bad " take ", but the pedigree strain S.55 was in general better than the commercial lot.

Smooth-stalked meadow grass made a fairly dense sward, but the total growth was small (appreciably less than rough-stalked meadow grass). The difference between the four bred strains was relatively small, but the commercial strain was the poorest in respect of total ground cover.

Phalaris : three lots of *Phalaris* were under test (including one lot of Australian *Phalaris tuberosa,* and two bred lines). None of these established well and the growth was negligible.

The legumes. None of the clovers proved themselves productive compared with the grasses, even during the first harvest year. Among the *red clovers* (seven strains of which were under trial), the wild red types gave the most keep and formed the largest individual plants. The Montgomery were next best, whereas ordinary late-flowering red was still poorer, and the broad red a complete failure. The establishment and overwintering of the various strains of red clover in the seeding and first harvest years respectively have been shown in Table III above. It will be seen that on the whole the initial establishment was satisfactory throughout, although significantly better (as measured in October, 1936—five months after sowing) in the wild and Montgomery types than in commercial late and broad reds. The data in respect of persistency into May and October of the first harvest year are of practical importance, and show that the wild red forms have persisted much the best. It is significant too that the bred (pedigree) lots have shown up to better advantage than their commercial counterparts, both in the case of wild red and Montgomery red. The marked falling off in plant numbers in the ordinary late and broad reds during the course of the first winter is more emphatic under the severe conditions of the hills than would ordinarily be expected under lowland conditions. These results are in general accord with expectation, based upon experience gained with commercial red clovers on cultivated hill farms in Wales.

Alsike clover. In the seeding year alsike had been among the most promising of the legumes, but like the commercial red clovers it failed appreciably to persist into the first harvest year, and made no more than a nominal contribution to the herbage. A few plants, however, persisted to the end of the first harvest year.

White clover. Kentish wild white clover was sown on a large number of plots in simple one grass—one clover mixtures. It made no appreciable contribution to the herbage until about mid-summer of the first harvest year, when on the average it contributed from about 10—15 per cent of the herbage cover. Its season of active growth was, however, short, and by the end of September its contribution was again negligible. Commercial Kentish wild white provided the best cover in the first harvest year, being appreciably denser than any of the pedigree strains. None of these latter had established themselves as well as Kentish. The mountain type (S.134) provided the poorest cover, representing only 11 per cent of ground covered, as against 33 per cent in the Kentish lot, and 17 per cent in the two bred lots (S.126 and S.118). These data are based on readings made in July-August, 1937.

Lotus major. The pedigree strain (S.121) gave appreciable keep, comparing quite favourably with the best of the red clovers and giving more keep than commercial red clovers or any white clover. The commercial strain was, however, much poorer, having overwintered less well and the plants that remained into the first harvest year were not spreading as much as those of S.121. Having regard to the heavy seed rates (15 lb. per acre), however, the stand of *Lotus* was on the whole disappointing.

Subterranean clover. There was a satisfactory establishment in the seeding year (Table II), but only a few plants had become re-established in the first harvest year. The indications are that subterranean clover has little or no place in seeds mixtures for hill lands in Wales. The very late-flowering form (Bass strain) appears to be better than the earlier flowering forms, and a few plants of this have occurred even in the later harvest years, although their total growth has been negligible.

(3) *The autumn period* (1937). The trial area was grazed by sheep during October, and a mow over cut followed to remove stemmy top growth. Growth had now stopped completely, while most species showed a tendency to " winter burn ". This was especially true of cocksfoot, including the pedigree strains (commercial had largely died out). During the autumn the leafy strains in most grasses had shown to considerable advantage. The following statement, based on observations made on September 14th, indicating the relationship of the different strains in respect of growth and ground cover in cocksfoot is typical :—

Relative growth and ground cover in the different types of cocksfoot (14/9/37).

Commercial	6	
Pedigree hay type (S.37)	60	
Pedigree pasture-hay types (S.26 and S.142)	79	84 (pasture types)
,, pasture-mop (S.143 and S.146)	87	
,, extreme pasture (S.29)	85	

Notes made in early December, 1937, show that rye-grass, dogstail, fine-leaved fescue and smooth-stalked meadow grass were very wintergreen, while all other species had more or less completely winter-burned. " Heaving ", that is, a lifting of plants above the general level of the surface soil, had been very severe on the whole area in the winter of 1936-37, and although less general this phenomenon was again marked in the subsequent winter of 1937-38 (first to second harvest year).

The Second Harvest Year (1938).

Notes were made at various periods during the year, and a botanical analysis of the swards was conducted ((a) series only) in early September. On 23rd March the following manures were applied :

(a) series Basic slag at 10 cwt. per acre to half of each plot
(b) series Lime (CaO) ,, 2 tons ,, ,, ,, ,, ,, ,, ,,
(c) series Basic slag 10 cwt. and lime 2 tons per acre to half of each plot.

Partly because of the spring drought of 1938 the commencement of growth was again extremely late on the plots. Bent made the earliest and best growth, but, as in the first harvest year, the leafage became " rusted ", and had an unpalatable appearance. In early May sweet vernal and cocksfoot were each commencing active growth, while soon afterwards fog, red fescue and timothy were beginning to grow. The next in earliness were rye-grass (especially S.23) and meadow foxtail. The other species, including dogstail, the meadow grasses, tall and meadow fescue, and the clovers made no contribution to keep during the month of May. The manures applied as a top dressing in March had made no impression upon growth in any of the species.

After the break of the drought in June, the weather became relatively warm and conditions for growth subsequently proved to be good until well into the autumn. Notes made on September 2nd indicate that the swards as a whole had greatly improved in density and in vigour of growth when compared with the summer of 1937. Unsown bent which had made a strong indigenous appearance in the first harvest year had by the latter part of the second year harvest spread and was assuming dominance on many of the plots. In general, it was only the stronger-growing species notably fog, vernal, red fescue and the pasture strains of cocksfoot and timothy, which had been able to keep bent under control. In the case of plots sown respectively with fog, vernal and red fescue, bent contributed less than 10 per cent to the herbage (September, 1938), while the figure was 17 per cent and 18 per cent respectively for the pasture types of timothy and cocksfoot. By comparison the meadow foxtail plots contained 49 per cent bent, while plots sown with *Phalaris* (which had failed to establish) gave a figure of 62 per cent bent at this time.

As in the first harvest year, it was bent, vernal, fog, cocksfoot and timothy that gave the most productive swards in the second year. Greater distinction, however, was to be found now between the ordinary commercial strains and the bred types. The following statement relative to cocksfoot, timothy and rye-grass is typical of the behaviour of ordinary and leafy pasture strains in the second harvest year :—

	Percentage contribution to herbage, September, 1938	
	Commercial	*Leafy Pasture**
Cocksfoot	2	39
Timothy	6	43
Rye-grass	6	21
Average	5	34

Among the clovers, only white clover, a few of the red clovers and pedigree *Lotus major* were making any contribution to growth. Alsike clover (commercial strain only) and subterranean clover had practically disappeared. Of the red clovers, wild red proved the most persistent—S.140 being the best. The Montgomery types were less persistent that the wild types, whereas both the ordinary commercial late and broad reds had completely disappeared. Among the white clovers, the two bred forms S.126 and S.134, were now better than either S.118 (large-leaved) or ordinary Kentish. The position is therefore the reverse of that found in 1937, when Kentish was best and S.134 (mountain type) the poorest.

The Third and Fourth Harvest Years (1939 and 1940).

Relatively little critical data were collected from the trial during 1939. It is hoped that in 1940 (the fourth harvest year) complete yield and other evidence will be collected. The area as a whole improved greatly during 1939, and the swards became denser than hitherto. White clover (sown) had filled in well at the base, and in mid-September, 1939, was contributing on the average some 20 to 25 per cent to the herbage cover. In the grasses the pedigree leafy strains were in most cases holding their own, and this was in sharp contrast to many of the ordinary com-

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*Cocksfoot, S.26 ; S.142 ; S.143 ; S.146 and S.29.
Timothy, S.48 and S.50.
Rye-grass, S.23 and S.101.

TABLE VI.

To show the percentage area covered by major sown species. E.192 Exposure Area. Third harvest year, 13/9/39.

Species	*Per-centage area covered*	*Species*	*Per-centage area covered*	*Species*	*Per-centage area covered*
Timothy	15	New Zealand bent ...	63	Smooth-stalked meadow grass	12
Perennial rye-grass	3	Crested dogstail	3	*Phalaris* vars.	Neg.
Cocksfoot	33	Fine-leaved fescue	39	Red clover	4
Rough-stalked meadow grass	13	Meadow fescue	3	Alsike clover	3
Yorkshire fog	48	Tall fescue	1	White clover	25
Sweet vernal	21	Meadow foxtail	3	*Lotus major*	3
				Subterranean clover	Nil

mercial lines. Danish cocksfoot, for example, had practically disappeared from the plots in which it was sown.

Having regard to the swarding ability of the various species, irrespective of strain (see Table VI), the species contributing 30 per cent or more of the cover were: cocksfoot (33 per cent), fog (48 per cent), bent (63 per cent) and fine-leaved fescue (39 per cent). Those contributing between 20 and 30 per cent to their respective swards were vernal and white clover. Species forming between 10 and 20 per cent of the cover were timothy and meadow grasses (rough- and smooth-stalked). All others gave a figure of less than 5 per cent, and these included rye-grass, dogstail, the broad-leaved fescues, meadow foxtail, *Phalaris* and the legumes, other than white clover.

The response to slag and/or lime applied to part of each plot in March, 1938, has been negligible. No real difference was to be seen during 1938, but in the latter part of 1939 the clover appeared to be slightly more vigorous on certain of the re-manured plots. Also in a few grasses, notably the pasture strains of cocksfoot, red fescue and Yorkshire fog, there was a slight increase in general vigour that might be attributable to the manuring. The differences everywhere, however, were so slight as to make it quite certain that the top dressing had not paid for itself up to the end of the third harvest year (i.e. almost two years after the application).

E.193. The Rate of Seeding Trial

This experiment sown on May 12th, 1936, was designed to test the influence of seed rate upon the development of the pasture. Seven simple seeds mixtures were employed and these were each sown in quadruplicate (see Table VII). The mixtures consisted of perennial rye-grass (S.23) sown at from 5 lb. to 60 lb. per acre in the various plots; crested dogstail (1 to 10 lb. per acre) and Kentish wild white clover (1—10 lb. per acre).

TABLE VII.

To show the seeds mixtures sown in the rate of seeding trial.

	Plot number						
Species	*1*	*2*	*3*	*4*	*5*	*6*	*7*
Perennial rye-grass S.23	5	5	10	10	20	40	60
Dogstail (commercial)	1	1	2	2	4	8	10
Wild white clover (Kent)	1	4	2	4	4	8	10

Manuring and general management of the plots were similar to that already described, i.e. they received slag and nitro-chalk at time of sowing, but received no subsequent manuring. No yield data have been collected, but notes have been made from time to time on all the plots. Plant counts were conducted on some of the plots (Mixtures 1—4) during the seeding and first harvest years, while a complete botanical analysis was made in the summer of the first harvest year. Detailed studies on single " permanent quadrats " were begun in the autumn of the seeding year on one plot (a/1), and these were followed by similar studies on precisely the same sites during the first harvest year. The results have been fully reported upon by Davis (2).

Discussion of Results.

Germination and initial growth were very slow; the plots would not have been ready for their first grazing until quite three months after sowing. No grazing was carried out until October, when the plots were about five months old. In relation to density of herbage, the plots fell into three groups. Plots 1 and 2 (lowest seed rates) proved similar to one another, the herbage on them was sparse (80-90 per cent of bare ground). Plots 3 and 4 proved to be alike, having about half covered the ground by July, whereas Plots 5, 6 and 7 (seed rate from 28 to 80 lb. per acre respectively) had covered the ground well and showed no more than 10 per cent bare space. The data brought together in Table VIII are based on material collected from Mixtures 1-4 (the lower seed rates) in October of the seeding year.

TABLE VIII.

To show (1) the percentage ground covered by, and (2) the percentage establishment of rye-grass, dogstail and clover when at different rates of seeding. E.193, Exposure Area, seeding year, October, 1936.

Species	*Rate of seeding lb. per acre*	*Per cent*	
		Ground cover	*Establishment*
Perennial rye-grass	5	33	71.6
do.	10	35	47.2
Crested dogstail	1	16	83.3
do.	2	22	69.2
Wild white clover	1	4	61.3
do.	2	6	47.4
do.	4	9	31.4

These data show that an increase of seed rates, even where the total seeding is still low in relation to that normally used in practice, while definitely increasing the cover provided by the sown species, does not do so in direct proportion to the increased seed rates. This is further confirmed when the figures for percentage establishment (based on plant numbers) in the sown species are considered. Similar data showing the percentage area covered by sown species at the different seed rates and based on botanical analysis made in the following year (August, 1937) are given in Table IX. These also show that an increase in the rate of seeding is not reflected proportionally in an increased ultimate ground cover. There is, however, up to a point the general trend towards increased density of sward as seed rate is increased.

TABLE IX.

To show the percentage ground covered by rye-grass, dogstail and white clover when sown at a number of different seed rates. E.193, first harvest year, 1937 (the rate of sowing in lb. per acre is shown in brackets).

Species	*Percentage ground covered*				
Rye-grass	18 (5)	27 (10)	27 (20)	37 (40)	39 (60)
Crested dogstail	8 (1)	8 (2)	10 (4)	10 (8)	10 (10)
White clover	12 (1)	19 (2)	19 (4)	22 (8)	18 (10)
Total	38 (7)	54 (14)	56 (28)	69 (56)	67 (80)

It would appear on the basis of these figures that no material advantage has accrued from an increase in the rate of seeding of the three species concerned, beyond the following points :—

Rye-grass	......	40 lb. per acre
Dogstail	......	2 ,, ,, ,,
White clover	......	2 ,, ,, ,,

Observations relative to yield in the first harvest year show that the total growth on the plots was small : this was a general phenomenon on the trial area as a whole. Differences in the total amount of keep offered were apparent, however, as between the plots. Those sown at the heaviest seed rates proved to be the most productive, and those sown at the lightest seed rates were, on the balance, the least productive, the increased yields showing a relationship to the seed rate in the major sown grass (i.e. perennial rye-grass). The statement hereunder shows the relative yields (with the heavy seed rate = 100) from plots where rye-grass was sown at 5, 10, 20, 40 and 60 lb. per acre respectively. These figures relate to three different dates in the first harvest year. The general tendency during the course of the year has been for the plots to become more even with respect to yield, botanical composition and general appearance. This is suggested (re yield) by the figures given in the following statement :—

Relative yields at three dates in first harvest year.

Seed rate of rye-grass	*3/5/37*	*29/5/37*	*Early August, 1937*	*Average for year*
5 lb. per acre	25	60	50	45
10 ,, ,, ...	50	70	75	65
20 ,, ,, ...	75	80	85	80
40 ,, ,, ...	90	90	95	93
60 ,, ,, ...	100	100	100	100

The influence of the different seed rates was noticeable well into the second harvest year. The difference has, however, been gradually getting smaller and the plots becoming less distinct. At the end of the third harvest year (December, 1939) the difference between plots was small and had become largely masked by the spread of unsown indigenous bent, which was by this time assuming dominance on all the plots. The influence of the heavy seed rates in rye-grass is still perceptible, however, but only on critical examination of the plots. No difference can be noted with regard to the different seed rates in either dogstail or white clover. These notes are based on observations made on the plots : careful analyses which it is hoped can be carried out during 1940 on the plots may reveal small differences that cannot be otherwise observed.

E.194. To Test the Influence of Yorkshire Fog, Cocksfoot and the Rye-grasses when added to a Simple Mixture.

This experiment was primarily designed to test the influence of Yorkshire fog when included at different seed rates in an otherwise common (basal) mixture. There were seven seeds mixtures, and these were sown in 1/200th acre plots replicated eight times. It had been hoped to test the influence of differential management (e.g. hard grazing from the outset against more lenient grazing), but for various reasons this has not proved practicable. Details of the seeds mixtures used are given in Table X.

Mixtures 1 to 4 differ only in the amount of fog included with the basal seeds mixture. Cocksfoot (leafy) is added in Mixture 6, while heavier seed rates of Italian and perennial rye-grasses respectively are made in Mixtures 5 and 7.

TABLE X.

To show details of the seeds mixtures in lb. per acre. E.194 Exposure Area. Sown 12/5/37.

Species	*Number of Mixture*						
	1	*2*	*3*	*4*	*5*	*6*	7
Italian rye-grass (commercial)	5	5	5	5	20	5	5
Perennial rye-grass (S.23)	10	10	10	10	10	10	30
New Zealand bent	5	5	5	5	5	5	5
Crested dogstail (commercial)	2	2	2	2	2	2	2
Kent wild white clover	2	2	2	2	2	2	2
Yorkshire fog	—	5	10	20	—	—	5
Cocksfoot (S.26 and S.142)	—	—	—	—	—	20	—

Discussion of Results.

The take of seeds was good throughout. The plots containing Yorkshire fog as part of the mixture were the first to produce feed of grazing value, these plots being ready for grazing appreciably earlier than those from which fog had been omitted. Notes made in October, 1936 (five months after sowing) on plots that had not been grazed showed that the inclusion of fog in the mixtures effected a marked increase in yield when compared with similar plots in which fog was omitted. These data have been summarized in Table XI. The figures for botanical composition show that fog tended to become dominant on the plots where it had been sown, and this was particularly true where fog had been used at 20 lb. or 10 lb. per acre. Even at a seeding of 5 lb. per acre, fog was definitely suppressing the other species. The surprising feature was that neither Italian rye-grass nor the pasture perennial rye-grass (S.23) exhibited any appreciable aggressiveness. Italian rye-grass in fact showed no considerable vigour at any time, even though the take as such was good. Both rye-grasses were adversely affected by the competition of fog and this was to be noted from the commencement. By the autumn of the seeding year bent also had become prominent, later to become distinctly aggressive and holding its own in competition with fog, except on plots where the latter had been sown at 20 lb. per acre. Dogstail and white clover were never aggressive, and did best in the mixtures (e.g. Mixtures 1 and 5) from which both fog and cocksfoot were excluded. The heavier seed rate of 20 lb. Italian rye-grass (compare Mixtures 5 and 1) seemed to have no real influence either in relation to yield or composition of the plots. Similarly increasing the seed rate of rye-grass (S.23) to 30 lb. per acre (compare Mixtures 7 and 2) appears to have been largely ineffective. The inclusion of 5 lb.

TABLE XI.

To show the percentage (area) composition and the approximate total yields in the seeding year. Based on records made 16/10/36. E.194, Exposure Area.

Mixture No.	*Description*	*Percentage area covered*								*Growth (estimated cwt. dry grass per acre)*
		Italian rye-grass	*Perennial rye-grass*	*Bent*	*Crested dogstail*	*Wild white clover*	*Cocksfoot*	*Yorkshire fog*	*Other unsown spp.*	
1	Basal mixture (see Table X)	5	26	44	11	5	—	9*	T	3
5	,, ,, with excess Italian rye-grass	5	15	60	10	5	—	5*	T	3
6	,, ,, plus 20 lb. cocksfoot	5	10	30	5	5	40	5*	T	8
2	,, ,, plus 5 lb. fog	3	10	25	4	3	—	55	T	5
7	,, ,, plus 5 lb. fog with excess perennial rye-grass	2	10	26	2	2	—	58	T	8
3	,, ,, plus 10 lb. fog	T	2	22	2	T	—	74	T	6
4	,, ,, plus 20 lb. fog	T	T	5	T	T	—	95	—	9
	Averages									
1 5 6	Average when no fog sown	5	17	45	9	5	13	6	T	5
2 7 3	Average when fog sown 5-10 lb.	2	7	24	3	2	—	62	T	6
4	Average when fog sown 20 lb.	T	T	5	T	T	—	95	—	9

*Not sown.

per acre of fog tended to swamp any increased production of rye-grass that might have accrued from the increased seed rate. Cocksfoot established well in the absence of fog, and was definitely more vigorous, and therefore more aggressive, than the rye-grasses sown with it (Mixture 6). By the first harvest year, bent was much more aggressive than cocksfoot, however. From this time onwards bent was the dominant species on all plots in which fog had not been sown.

It is to be emphasized that the whole trial area has had lenient grazing treatment from the commencement. This has to a certain degree tended to favour Yorkshire fog when compared with bent. Having regard to the trend of the evidence generally, it is clear that these two species, bent and Yorkshire fog, are to be regarded definitely as aggressor species under extreme hill conditions. Furthermore, it is quite unlikely whatever the grazing treatment that the accepted "better grasses" (e.g. rye-grass, cocksfoot, dogstail, clover) sown under high elevation conditions would possess vigour sufficient to oust, or even materially to check, the growth of bent and fog. There appears to be good evidence to suggest that both these latter grasses can play a useful part in seeds mixtures designed for hill conditions. Fog establishes rapidly from seed, therefore tending to act as a "nurse" and also provides valuable feed at this period. If grazed hard fog can be kept in check so that the species of less rapid growth (bent, dogstail and clover) can become properly established. Bent establishes only relatively slowly from seed, but under the conditions of this trial the establishment following a seed rate of 5 lb. per acre has proved highly satisfactory. Once established, bent has become aggressive and has been able to maintain itself to become co-dominant in plots sown with 5 lb. or even 10 lb. per acre of fog.

It has not been possible to get complete data with regard to yield on the plots. Quadrat cuts on four replicates of the plots were however made on September 22nd, 1937. The herbage cuts obtained represented the total growth for the first harvest year (the plots having been fenced off for that purpose). The yields calculated to the basis of cwt. (= 100 lb.) per acre of air-dried grass are given in Table XII.

Table XII also shows the botanical composition of the herbage representing the growth for the whole of the first harvest year. It will be noted that fog and bent have been the chief contributing species, and that the species usually valued highly under normal lowland conditions have proved low in relative yielding power, even in their first harvest year. The data are of considerable interest inasmuch as they indicate the relative competitive power

TABLE XII.

To show the botanical composition (per cent productivity) of the herbage on plots sown with and without Yorkshire fog, included in the mixtures. Average yields are also shown (cwt. = 100 lb. per acre). E.194, Exposure Area. Total grass crop for first harvest year to 22/9/37.

	Mixtures averaged	*Italian rye-grass*	*Perennial rye-grass (S.23)*	*Bent*	*Crested dogstail*	*Wild white clover*	*Cocksfoot (leafy)*	*Yorkshire fog*	*Other unsown spp.*	*Total average yield; first harvest year*
Plots in which fog is omitted	Nos. 1, 5, 6	T	4	82	3	3	3*	4**	1	25.3 cwt.
Fog sown at 5 or 10 lb. per acre	Nos. 2, 3, 7	T	4	51	1	2	T	41	1	22.9 cwt.
Fog sown at 20 lb. per acre	No. 4	T	2	19	T	1	—	78	T	22.1 cwt.

*Representing 9 per cent of the herbage on plots where cocksfoot was sown. **Unsown.

of bent and fog, both in relation to one another and in relation to the other sown species. Bent has given the higher yield, and it has proved rather less aggressive than fog in relation to rye-grass, dogstail and clover. Fog included in the mixture at 5 lb. or 10 lb. per acre has materially reduced the productivity of bent, and has tended to decrease all other species. When the seed rate of fog is increased to 20 lb. per acre the contribution of rye-grass, dogstail and clover has been reduced to a minimum, while bent has contributed less than one-fifth to the total herbage. Fog itself has virtually taken charge and dominated these plots. The figures for total average yield on the various plots are of further interest. The yield is highest where fog is omitted, and is lowest where fog is included at the heaviest seed rate (20 lb.), but even 5 and 10 lb. fog has significantly reduced the gross yield by nearly 2½ cwt. per acre, or about 10 per cent. Having regard to the composition of the herbage this simply means that bent has proved slightly the more productive species under these conditions.

E.199. To Test Simple Mixtures (One Grass One Clover) on the more Peaty Portion of the Field.

This trial was sown in non-replicated plots most of which were 1/20th acre in size and occupied a peaty hollow in the experimental field. Details of the seeds mixtures used are given in Table XIII. Particulars relative to cultivations, sowing date and manuring are those of the field as a whole, and already described.

TABLE XIII.

To show details of seeds mixtures employed (lb. per acre). E.199, Exposure Area, sown 12/5/36.

Species	*Number of Mixture*							
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Perennial rye-grass (S.23)	40	—	—	—	—	—	—	—
Timothy (S.51)	—	40	—	—	—	—	—	—
Timothy (S.48)	—	—	40	—	—	—	—	—
Cocksfoot (S.142)	—	—	—	40	—	—	—	—
Crested dogstail (commercial)	—	—	—	—	40	—	—	—
Meadow fescue (commercial)	—	—	—	—	—	40	—	—
Tall fescue (mixed: pedigree and commercial)	—	—	—	—	—	—	40	—
Meadow foxtail (S.55)	—	—	—	—	—	—	—	40
Kentish wild white clover	3	3	3	3	3	3	3	3

Observations made on the plots six weeks after sowing show that the initial soil germination and take was good in rye-grass, timothy, cocksfoot and dogstail, but poor in the fescues and foxtail.

The peaty surface soil at this time tended to be " soft and puffy ", and needed consolidation. White clover was a fair take everywhere. In October (five months after sowing) perennial rye-grass seemed among the most promising lot; it was dense and green, having proved very palatable, but not very vigorous. Timothy, which had in early summer appeared so dense, was now an open sward, there having been apparently enormous seedling casualties (estimated at quite 80 per cent of those initially established). There was no difference between S.51 (hay type) and S.48 (pasture type) timothy in this or any other respect. Cocksfoot (pasture type) had made leafy growth during the summer, but the leafage showed much burn, consequently was not palatable, and had to be scythed off the plots. The ultimate take of cocksfoot was good. Crested dogstail established well and proved very palatable, but did not make as dense a sward as the rye-grass. In contrast to their poor growth about six weeks after sowing, meadow foxtail and meadow fescue were well established by the late autumn, and had made considerable leafy growth. The leafage of foxtail was badly rusted (*Puccinia dispersa*) and showed much leaf burn, distinct as such from the rust attack Tall fescue was a fairly good take in the autumn.

With regard to the subsequent behaviour of the different lots on the peat, rye-grass (S.23) has maintained itself as a fairly dense sward, but the growth has always been small. Dogstail has behaved somewhat similarly, but the sward has been less dense than that of leafy rye-grass. Timothy has produced an open sward and has not proved productive after the seeding year. There have been no material differences between the behaviour of timothy S.51 and S.48. Cocksfoot has maintained itself well and has been, on the whole, the most productive lot in the trial. The leafage has, however, tended to be refused by the grazing animal, and except for a short summer period in each year cocksfoot leafage was excessively burned. Meadow fescue, tall fescue and meadow foxtail have made very little contribution to keep after the seeding year.

General Considerations—Lessons to be Drawn on the Basis of all the Trials under Review.

Four trials have been reviewed. These have all been sown on one area of exposed hill land standing at an elevation of 1,300 ft. The manuring has been such as would normally be practised in hill reclamation work, being largely based on phosphates and lime (with nitrogen applied at time of sowing). The grazing treatment has probably been more lenient than would normally be the practice.

The trials considered as a whole, and over the period to the end of the third harvest year, provide valuable data with regard to the behaviour of individual species and strains when sown in simple mixtures. They provide data also for assessing the value of different species as components of seeds mixtures specifically designed for the more exacting climatic and soil conditions of the Welsh hills. The results obtained quite probably have wider application in relation to the general problem of compounding seeds mixtures designed for use in hill reclamation work in Britain as a whole.

On the basis of the trials under review, the commoner grasses and clovers may be placed in three groups in order of their apparent value as components of seeds mixtures for hill reclamation. In Group 1 are placed the more suitable species; in Group 2, species that establish well but attain to only a low standard of production, and in Group 3, species of low value, including those failing to make any appreciable contribution to the swards at any time during the first three years. The various species are listed below under these three headings: because sharp differences are found in the agronomic behaviour of contrasting strains within the same species, it will often be necessary to differentiate between such strains, and to place them in different groups.

Group 1 (*first rate*). Timothy (all strains, but in particular the leafy pasture strains); cocksfoot (the leafy pasture strains only), bent (*Agrostis tenuis*), Yorkshire fog; crested dogstail, red fescue, wild white clover, wild red clover (late and leafy types), *Lotus major*.

Group 2 (*second rate*). Perennial rye-grass (all forms), rough-stalked meadow grass, smooth-stalked meadow grass, sheep's fescue, alsike clover, Montgomery red clover,* wild red clover (ordinary commercial).

Group 3 (*third rate*). Italian rye-grass, Danish cocksfoot, meadow fescue, tall fescue, hard fescue, meadow foxtail, sweet vernal grass,† *Phalaris* spp., broad red clover, late-flowering red clover, subterranean clover (all forms).

In formulating seeds mixtures for hill reclamation work, chief reliance should be placed upon species and/or strains placed in Group 1. In special circumstances, and for particular purposes, certain of the species belonging to Group 2 might be used, but those placed in Group 3 would seem to have no useful part to play in seeds mixtures for the high hills. Having regard to the evidence generally there is every indication to show that the aim in making new and improved pastures on the hills (at least in the first phase of reclamation) should be to produce swards in which bent and white clover would be the dominant species. Both of these are slow to establish from seed, but once established and given reasonable manuring and management they can be maintained more or less indefinitely. Three seeds mixtures designed specifically for hill work are suggested below. Yorkshire fog is added to the one and omitted from the others. Fog has many valuable properties in connexion with hill grazings : it grows from seed readily and quickly, while it may persist well into the later harvest years. It has the disadvantage, however, of smothering other species sown with it. Furthermore, while in the young and actively growing leafy stage, it is quite palatable. Fog, however, rapidly becomes relatively less palatable and this fact adds to its aggressive nature in the sward. Fog, to be useful as a component of the seeds mixture, must be grazed hard from the outset. Employed in this way it can act as a " nurse " to the developing " bent-white clover " sward, while providing feed quickly in order to draw stock on to the land to graze, to tread and to excrete.

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*Certain of the bred forms of the Montgomery type persisted well into the first harvest year.

†Sweet vernal grass was very productive, but at all times appeared unpalatable and is therefore here placed in Group 3.

Tentative suggestions as to seeds mixtures for hill reclamation.

	(1)	*(2)*	*(3)*
Species	*With Yorkshire fog*	*Omitting fog*	*Ultra-simple with timothy as " nurse "*
Yorkshire fog	4	—	—
Cocksfoot (mop S.143)	4	5	—
Timothy (Scotch)	2	5	20
Timothy (S.48)	2	3	—
Timothy (S.50)	2	3	—
Bent (*Agrostis tenuis*)	4	3	3
Crested dogstail	2	2	—
Red fescue (e.g. S.59)	2	2	—
Wild white clover	2	2	2
Total lb. per acre	24	25	25

In all three mixtures reliance for the ultimate sward is based on bent and wild white clover. Yorkshire fog is used as " nurse " in Mixture 1, while cocksfoot, timothy, dogstail and red fescue are used as potentially valuable ingredients, especially during the early years of the sward. In Mixture 2 greater reliance is placed on cocksfoot and timothy as " nurse " during the first years, while in Mixture 3 complete reliance is placed on timothy as " nurse ", and to provide the bulk of the grazing during the first year—only commercial timothy the seed of which is relatively cheap need be employed in this case. Wild red clover, Montgomery red clover (e.g. S.123), alsike clover and *Lotus major* would all be appropriate additions to each of the mixtures suggested above. Ribgrass, though not included in the trials under discussion, is another species that could usefully be employed.

The important part played by bent and fog suggests very strongly that the plant breeder should turn his attention to the *ad hoc* breeding of strains developed especially for hill conditions. A certain limited amount of preliminary selection work has been done on both species at the Welsh Plant Breeding Station, but an extension of this work is suggested on the basis of results that have accrued from the present trials.

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References.

1. Davies, William (1927). Seeds mixture problems: field trials. *Welsh Plant Breeding Station Bulletin*, Series H. No. 6. Aberystwyth.
2. Davis, A. G. (1938). The establishment, winter resistance, persistency and productivity of certain strains of grasses and clovers sown at elevations of 400 and 1,300 ft. under different types of management (*unpublished thesis*).
3. Osvald, H. (1937). Achievements and aims in modern Swedish grassland management. *Report of 4th Int. Grass. Congress*, Aberystwyth.
4. Thomas, M. T. (1936). Investigations on the improvement of hill grazings. *Welsh Plant Breeding Station Bulletin*, Series H. No. 14. Aberystwyth.

EXPERIMENTS ON THE WINTERING OF MOUNTAIN EWES.

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Before describing these experiments on the wintering of mountain ewes, emphasis should be laid on the following three facts :

(1) That the experiments were not designed in any way to give critical live-weight increases, but were an endeavour to find out some of the effects of different methods of feeding and wintering mountain ewes on their subsequent ability to thrive on rough mountain grazings.

(2) That even the fields on which these ewes were wintered ranged between 900 and 1,000 ft. above sea level, and that the improved hill pasture on which one lot was grazed stood at an altitude of approximately 1,100 ft. The summer pasture of these sheep ranged between 1,500 and 2,000 ft. above sea level.

(3) That the ewes were the weaker ones which normally would be drafted down from the mountain pasture at Christmas. These ewes were served by the ram while grazing on the mountain pasture. This explains to a certain extent the relatively low live weights and lambing percentages.

One of the greatest problems that the mountain sheep farmer has to contend with is the wintering of his stock. On some of the higher mountain farms the amount paid for wintering may be two, or even three, times as much as the actual rent of the farm. The general custom has been to send the lambs, and a proportion of the younger ewes, down to winter on lowland farms, leaving the older ewes and wethers on the mountain pastures throughout the winter. Under these conditions in a normal year the lambing percentage will vary from 60 to 75 per cent, but in a bad year during which snowstorms have been experienced, the lambing percentage may fall as low as 20 per cent, or even lower in extreme cases.

When fat lamb production is a paying proposition, the amount of lowland available for wintering becomes limited, and the price of wintering per head correspondingly rises, so that it is possible to visualize a limitation of available lowland pastures for wintering. Another factor which must be considered, and which affects the problem, is the amount of capital available to the lowland farmer to invest in a "flying flock" as an alternative to taking in wintering sheep.

Various methods of circumventing the sending down of mountain sheep to the lowlands for wintering have been spasmodically tried by a number of people without correlation with the after-effects, therefore, with very indefinite and contradictory results, Some sheep farmers maintain that no ill effects are discernible, while others hold that artificial feeding impairs the hardiness of the ewes and their ability to thrive on poor mountain pastures afterwards, and also that the lambing percentage suffers. If this is the case, then it is a very serious problem, because the fundamental virtues of the mountain ewe are its hardiness and its abilty to thrive and rear lambs on poor pastures. Whatever improvements are made in the conformation and the quality of the wool, etc., if they are made at the expense of hardiness, it will adversely affect the utilization of the higher land.

Experiments conducted on the Cahn Hill Improvement Scheme during 1933 to 1937 have proved that it is possible to winter mountain ewes and lambs by different methods of feeding and pasturage equally well with lowland pastures as far as live weight increase and visual indications of thriftiness are concerned. But the criterion is how these sheep thrive when turned back to the mountain in April and May. Owing to the fact that we have been running our open sheep walk at Nantrhys on commercial lines, we have been unable to follow up the effects of the different methods of wintering on the sheep during their life on the mountain pastures.

1937—1938 Experiments.

During the winter of 1937-38 six lots of ewes (five lots comprising seventy-five ewes each, and the other forty) were wintered on the following lines :—

Lot 1. Ordinary improved hill pasture
„ 2. Two feeds per day of dried grass
„ 3. Two feeds per day of maize
„ 4. 1½ hours per day on marrow-stemmed kale
„ 5. 1½ hours per day on timothy rows
„ 6. 1½ hours per day on winter foggage.

In addition to obtaining live weight increases and taking notes on the condition of the ewes, it was the intention to carry the experiment right through the sheep's life on the mountain, and also to ascertain the ability of the different lots to produce and rear lambs. As far as could be ascertained, no systematic experiments on these lines had been carried out previously.

During the winter of 1936-37 dried grass from the small experimental plant then installed at Pwllpeiran (headquarters of the Scheme) was fed to mountain sheep during the severe snowstorm that was experienced in March, 1937. It was found that whilst the ewes ate the dried grass fairly readily during the time the ground was covered with snow, difficulty was experienced in getting them to eat any quantity when the ground cleared, even though very little pasture was available. It is the general experience that it is difficult to get mountain sheep to take to hand feeding. For this reason, in order to give the dried grass and maize a fair trial, a preliminary sorting out period of about two weeks was put into operation in the fields adjoining the homestead. During this period dried grass and maize were taken to the fields every day, and the ewes that showed a partiality for dried grass and maize respectively were sorted out and separated until the requisite numbers for the feeding of dried grass and maize were obtained. In order to ensure that all the sheep included in the experiment were eating their share of the respective feeds, it was not found possible to obtain even starting weights for all the lots, but as far as possible an endeavour was made to even out the other factors, such as age and the condition of the ewes. On January 14th, 1938, the six lots were drafted to the various paddocks.

Dried grass fed ewes. Seventy-five ewes were placed in a permanent grass field of ten acres. This field had been mown for hay in the summer of 1937 and contained a fair amount of keep. Dried grass was fed in racks twice daily at the rate of 2 lb. per head per day. These ewes were the heaviest in average weight at the commencement of the experiment and were the only lot to increase in weight continuously throughout the winter period of the experiment, that is, to March 15th.

During this period they had made an average live weight increase of 8.90 lb. During the period March 15th to May 15th there was an average decrease of 3.66 lb. in the weight of the ewes. On this date (May 15th) the ewes and lambs were turned to graze on the unimproved mountain at Nantrhys. They were weighed again on August 24th and on December 15th. The weight recorded on August 24th shows that there had been an average increase in weight of 2.16 lb. since May 15th. By December 15th, however, the average live weight was 60.23, showing a loss of 4.07 lb. for the period August 24th to December 15th. Whilst this group of ewes had the heaviest average live weight on March 15th, they had fallen to third place by December 15th.

Table II shows that the percentage lambs reared from this lot was 78.35 per cent, that is, the second highest. These lambs had

TABLE I.

Average live weights of ewes, 1937-1938.

	14/1/38		1/2/38		15/2/38		1/3/38		15/3/38		15 and 18/5/38		24/8/38		15/12/38	
Group of ewes	*Lb.*	*Per cent*	*Lb.*	*Per cent*	*Lb.*	*Per cent*	*Lb.*	*Per cent.*	*Lb.*	*Per cent*	*Lb.*	*Per cent*	*Lb.*	*Per cent*	*Lb.*	*Per cent*
Improved hill pasture	55.80	100	53.20	97.0	51.50	93.3	54.50	99.0	54.00	98.1	58.27	106.0	63.60	116.0	63.96	116.2
Dried grass	56.90	100	58.30	102.3	58.90	103.3	62.40	109.6	65.80	115.6	62.14	109.1	64.30	113.0	60.23	106.8
Maize	55.90	100	56.90	101.7	56.85	101.7	61.50	110.0	65.50	117.0	61.45	109.9	65.84	118.0	64.10	112.6
Kale	51.90	100	53.50	103.0	50.80	103.0	54.10	104.2	58.30	112.3	58.50	112.4	62.6	120.7	62.78	120.9
Timothy rows	47.70	100	49.30	103.3	49.40	103.5	48.90	102.5	51.80	109.0	50.80	108.0	59.20	123.0	59.12	122.9
Winter foggage	49.14	100	47.70	97.3	49.70	101.2	51.40	104.7	55.09	112.2	55.80	113.6	61.08	124.4	61.43	125.0

TABLE II.

Lambing percentages and live weights of lambs, 1937-1938.

Group of Ewes	Ewes			Lambs						
	No. in expt.		Number aborted	Number dead at birth	Number of live births	Number reared	Per cent reared	Average live weight in lb.		
	Start	Finish						At birth	16/5/38	24/8/38
Improved hill pasture	75	75	—	3	60	59	78.60	5.90	19.80	41.90
Dried grass	75	74	—	1	60	58	78.35	6.30	19.16	43.20
Maize	75	68	2	4	53	53	78.00	6.84	23.30	45.90
Kale	75	73	3	2	51	49	67.12	6.17	19.50	39.50
Timothy rows	75	69*	1	6	45	42	60.85	5.30	17.90	41.50
Winter foggage	40	40	—	—	28	27	67.50	6.23	20.73	45.65

*2 only dead; 4 withdrawn from experiment.

TABLE III.

Chemical analyses of feeding stuffs used in the trials.

	No. of Samples	*Percentage*			
		Soluble Carbohydrates	*Crude protein*	P_2O_5	*Lime*
1937-38.					
Dried grass	13	37.05	15.00	0.92	1.15
Kale	4	43.74	27.26	1.53	2.20
Timothy rows : 1st period	2	48.08	6.25	0.35	0.40
2nd period	2	44.56	11.63	0.59	0.60
Winter foggage	4	45.17	16.35	0.82	0.79
Improved hill pasture	4	48.94	15.47	0.68	0.46
Maize	1	66.70	10.00	0.70	0.02
1938-39.					
Dried grass	4	43.32	15.17	0.93	0.99
Silage	4	39.56	13.02	0.69	1.47
Timothy rows	4	44.80	13.22	0.65	0.58
Winter foggage	4	38.07	21.15	0.94	0.60
Improved hill pasture	4	45.63	16.55	0.69	0.48
Maize	2	67.46	10.35	0.74	0.02

an average weight of 6.3 lb. at birth. 19.16 on May 15th, and 43.20 lb. on August 24th, when they were drafted down from the hill.

There was only one casualty in this lot of ewes. They gave no trouble in lambing and had a plentiful supply of milk. The lambs, which were second highest in average weight at birth, made good growth throughout the summer, though dropping to third place, in weight, by the end of August.

As the experiment proceeded one gained the impression that the dried grass fed sheep were in better condition and carried more "bloom" than any of the others. The fleece was full and of a creamy tint, and they had the appearance of fattening sheep. Undoubtedly at the end of the fortnightly weighing period they were all to appearances by far the best bunch. It was interesting to see these sheep walking in droves across the field to drink water in the stream after each feed.

Maize fed ewes. Seventy-five ewes were placed on a four-year-old ley that had been mown in 1937. The field was seven acres and contained a fair amount of keep. Maize was fed twice daily at the rate of 1 lb. per head per day. These ewes had the second highest average weight on January 14th, that is, 55.90 lb. By February 1st they had made an average live weight increase of 1 lb., but by February 15th they had lost a little weight due to the shortage of keep. At this stage it was decided to supplement the maize with ¼ lb. per head per day of good quality hay. By March 15th these ewes had made an average live weight increase of 9.60 lb. since January 14th, that is, a greater increase in weight than the dried grass group, though the maximum average weight was slightly lower. As in the case of the dried grass group there was a loss in weight of 4.05 lb. for the period March 15th to May 15th. By August 24th there was an average live weight increase of 4.39 lb. for this period on the mountain, and this average weight of 65.84 lb. was the highest weight recorded at this date. By December 15th the average weight had dropped to 64.10 lb., but this was the heaviest group at this date.

Seven ewes died during the winter period, and there was difficulty in lambing though the supply of milk was good and the ewes reared their lambs well. Two ewes aborted and four lambs were born dead. The percentage lambs reared was 78.0, and these lambs had the highest average weight at birth and throughout the summer on the mountain, reaching a maximum of 45.9 lb. when weighed on August 24th.

During the period that maize was fed these ewes showed the characteristic whitening of the fleece which is attributed to fed sheep.

Kale fed ewes. Seventy-five ewes were put on a ten-acre permanent pasture field which had been cut for ensilage in 1937 and which contained a similar amount of keep to the previous two fields. The ewes were turned into an adjoining field where there was a good crop of marrow-stemmed kale grown in rows. For the first period of the experiment they were allowed to graze the kale for 1½ hours per day, but as a result of a period of no live weight increase in the middle of February the time of grazing was increased to 2 hours per day. At the commencement of the experiment these ewes weighed 51.90 lb. and except for a period in the middle of February they continued to make good live weight increases during the winter period, gaining 6.4 lb. by March 15th. These ewes also made a small increase in weight during the period March 15th to May 15th. During the summer grazing on the mountain the ewes continued to increase in weight, reaching a maximum of 62.78 lb. per head by December 15th, that is, they put on weight during the period August 24th to December 15th.

In the course of the experiment two ewes died, three aborted, and two lambs were born dead. It is significant that the highest number of abortions occurred in the two most highly concentrated feeding groups (one in protein and one in carbohydrates), the kale having a crude protein content of 27.28 per cent, whilst the maize was a very concentrated starchy food.

The lambing average of this group was 67 per cent, and on the whole they gave little trouble in lambing, the supply of milk being plentiful and the ewes attentive to their lambs. The lambs averaged 6.17 lb. at birth and were heavier than those of the dried grass group when sent back to the mountain in May, though lighter at birth. These lambs, however, were the lowest in weight when drafted down in August, being 6.40 lb. per head lighter than the best, namely the maize group, and even 2 lb. per head lighter than the timothy rows group.

Timothy rows ewes. This batch of seventy-five ewes were placed in a stubble field in which a temporary seeds mixture had been sown with the cereal crop and the aftermath kept for wintering. The ewes were allowed access for 1½ hours per day to the pedigree timothy grown in rows in the adjoining field. Half of these timothy rows had been cut for hay and the other half were unmown.

The average weight of the ewes on January 14th was 47.70 lb. and this was the lowest of all the groups. There was very little live weight increase in the first few weeks of the experiment, and towards the end of February they had begun to lose weight. There were two reasons for this : firstly, up to this time the ewes had been grazing on the unmown part of the rows, and by the beginning of March all the green foggage had been eaten off, leaving only the dried stems; secondly, the keep on the temporary ley had become very scarce. At this juncture the ewes were allowed to graze for 2 hours on the mown timothy rows and were given access to a two-year-old pasture containing some foggage. By March 15th the ewes had an average live weight of 51.8 lb., but from then to May 15th, it fell to 50.8 lb. At Nantrhys during the summer the ewes reached a maximum live weight of 59.20 lb. by August 24th, and only lost 0.08 lb. by December 15th.

This was the most unsatisfactory group of all during the winter period, being, on the whole, weak and in poor condition. This may be due to the fact that until the beginning of March they grazed the unmown timothy rows, which contained a high percentage of dead material, and, in addition, that keep became scarce on the temporary ley. However, there was a marked improvement in the ewes during the summer, and they were in fair condition at the date of the last weighing.

Only 60 per cent of the lambs were reared; one ewe aborted and six lambs were born dead. The supply of milk was poor, and many of the ewes were inattentive to their lambs. This probably accounts for the number found dead at birth. These lambs weighed less than any of the others at birth, and when sent back to the mountain in May. During the summer they improved appreciably, and by August 24th were in fairly good condition and heavier than the others from the kale fed group.

Winter foggage ewes. This lot of forty ewes was turned into a four-acre two-year-old ley that had been mown for hay in the summer. They were given access for 1½ hours per day for the first period, and later for 2 hours, to another four-acre paddock of ley pasture that had been sown in 1936 without a nurse crop and closed to stock from August, 1937. This provided an ample bite of " put-up " green foggage.

Owing to scouring, these ewes lost an average of 1.44 lb. for the first fortnight, but from that date on they increased continuously in weight until the final weighing They made good live weight increases at Nantrhys, and by December 15th their percentage increase in weight was higher than that of any other group.

There were no casualties among these ewes: none aborted and no lambs were born dead. The ewes gave no trouble with their lambs, and out of a total of twenty-eight births twenty-seven were reared. Nevertheless, the lambing percentage was low, being only 67.0, as compared with 78.0 in the best group. These lambs weighed 6.23 lb. at birth, 20.73 lb. when turned to Nantrhys in May, and were second best at 45.65 lb. per head on August 24th, that is, a close second to the maize group.

Hill improved pasture group. As a control this lot of seventy-five ewes were turned on to a block of improved hill land thirty-two acres in extent. This block had been grazed with cattle and sheep in the autumn, but still contained a fair amount of keep at the time of the commencement of the experiment.

This group was the third highest in average weight at the commencement of the experiment. The ewes lost appreciably in weight until the end of February. This was due to the exposed position of the pasture which stands between 1,100 and 1,200 ft. above sea level. During the first week in March the ewes were turned for a short while on to an adjoining paddock of improved pasture, affording more shelter than the original paddock. From the end of March until the last date of weighing the ewes made a continuous increase in live weight. By December 15th their average weight was 63.96 lb. and they were in a very good and thriving condition. At this date, together with the foggage group, they would have undoubtedly fetched the highest price in the market as draft ewes.

This group had the highest lambing average, namely, 78.6 per cent. No ewes aborted and three lambs were found dead at birth. The lambs were 0.6 lb. heavier than those of the timothy rows group and were the third best when turned to the mountain in May. However, they did not make the growth expected of them during the summer, and weighed only 41.9 lb. per head when drafted down on August 24th.

1938-1939 Experiments.

During the winter of 1938-39 an experiment similar to that of the winter 1937-38 was carried out, but with some modifications. There was no marrow-stemmed kale available, therefore a silage fed group was substituted for the kale fed lot.

It was felt during the previous winter that the groups of seventy-five ewes were too big to handle conveniently, and it was decided, therefore, to have only forty-five ewes in each lot during 1938-39. Moreover, it was felt that the ration of 2 lb. per head per day of dried grass and 1 lb. of maize produced a ewe that was probably in too good condition to be turned back in May on to a poor mountain pasture. For this reason the ration of dried grass was reduced to 1 lb. per head per day and of maize to ½lb. Further, in the 1937-38 experiments seven out of the seventy-five ewes fed on maize died during the winter period, the cause of death being similar to braxy or " struet ", the ewes dying suddenly and generally being found dead in the morning. It was thought that a reduction in the amount of maize fed might reduce the percentage losses.

TABLE IV.

Average live weights of ewes, 1938-1939.

	12/1/39		30/1/39		13/2/39		27/2/39		27/3/39		18/5/39		9/9/39		15/12/39	
Group of ewes	*Lb.*	*Per cent*	*Lb.*	*Per cent*	*Lb.*	*Per cent*	*Lb.*	*Per cent*	*Lb.*	*Per cent*	*Lb.*	*Per cent*	*Lb.*	*Per cent*	*Lb.*	*Per cent*
Improved hill pasture	53.20	100	49.31	92.70	49.14	92.37	50.00	94.0	52.03	97.80	42.40	79.70	58.80	110.52	58.93	110.75
Dried grass	53.51	100	52.80	98.67	53.40	99.79	53.00	99.0	57.00	108.39	47.15	88.11	60.40	112.87	55.29	103.14
Maize	55.07	100	53.13	96.47	55.36	100.52	55.80	101.32	59.24	107.57	47.89	86.70	58.57	106.35	59.57	104.50
Silage	49.00	100	47.37	96.67	46.35	94.59	46.23	94.32	44.42	90.65	44.60	91.14	59.75	121.94	60.09	122.63
Timothy rows	53.20	100	54.74	102.89	55.20	103.76	53.45	100.47	59.50	111.26	49.00	92.10	61.33	115.28	56.50	106.01
Winter foggage	51.64	100	52.26	101.20	55.06	106.62	52.73	102.11	56.65	109.70	49.30	95.46	55.69	107.84	55.26	107.01

Great difficulty was experienced in getting the silage lot to eat, and although they were coaxed in every way, even at the end of the period, some of the ewes would not eat the silage and had to be taken away from the experiment to prevent them from dying of starvation. In contrast, after the preliminary period there was no difficulty in getting the dried grass and maize fed group to eat their respective feeds.

Dried grass group. This lot of forty-five ewes was turned into a ten-acre field that had been cut for ensilage in the summer of 1938, and had been grazed fairly bare in the autumn ; they received two feeds per day of dried grass at the rate of 1 lb. per head per day.

The reduction in the dried grass ration was reflected in the ewes in that they were losing weight until the end of February. By this time they had lost an average of 0.51 lb., but by March 27th there was an average live weight increase of 3.46 lb. on the original weight. Between March 27th and May 18th, at which date they were turned back to graze on the mountain pasture at Nantrhys, the ewes had lost 9.85 lb. per head. It is significant that all the groups lost weight during this period, except those fed on silage. This was due to the cold dry weather in April and early May which resulted in a shortage of keep. At this date the ewes did not look so well, nor did they carry the bloom of the corresponding group of the previous year. During the summer on the hill the ewes continued to increase in live weight, and for the period May 15th to September 9th gained 13.25 lb., but there was an appreciable drop in the weights by December 15th, the average loss being 5.11 lb. since September 9th.

There were no casualties during the winter, no ewes aborted, and as in all the other groups, only one lamb was found dead at birth. The ewes gave no trouble in lambing and reared their lambs satisfactorily. Out of forty-one live births only thirty-four lambs were reared. These lambs weighed 6.70 lb. at birth and 18.14lb. when turned back to the hill. The lambs did not make such good growth during the summer grazing on the mountain as did the dried grass group of the previous year, weighing only 40.44 lb. on September 9th as against 45.62 lb. in the best group.

Maize fed group. This lot of forty-five ewes was turned to graze on a 16-acre field which had been reclaimed from rushes and *Molinia.* Incidentally this field is very well sheltered, being surrounded by woodland. Though this field has a bigger acreage than any of the others, the grazing area, if anything, would be less, because six acres of the best part received a heavy dressing of lime compost in January and another area of five acres was heavily dressed with ground limestone in February. The ewes were given

TABLE V.

Lambing percentages and live weights of lambs, 1938-39.

	Number in experiment			*Number aborted*	*No. born died*	*No. live births*	*Number reared*	*Per cent reared*	*Average live weights of lambs in lb.*		
	No. at start	*Number died*	*No. at* 18/5/39						*At birth*	*18/5/39*	*9/9/39*
Improved hill pasture	45	—	45	—	1	32	27	60.00	5.58	17.11	41.6
Dried grass	45	—	45	—	1	41	34	75.50	6.70	18.14	40.44
Maize	45	5	40	—	1	32	29	72.22	6.28	21.58	45.44
Silage	45	1	44	—	1	23	22	50.00	5.28	14.70	35.87
Timothy rows	45	1	44	—	1	39	30	68.18	6.71	18.66	40.00
Winter foggage	45	—	45	—	1	35	35	77.77	6.48	21.57	45.62

½lb. per head per day of maize, but the reduction in the ration did not give the anticipated result as regards mortality in the ewes, since the percentage deaths was higher than in the previous year.

The ewes weighed on an average 55.07 lb. at the commencement of the experiment, and were the heaviest of all the groups at this date. By January 30th they had lost 1.94 lb. in weight per head, but from this date until March 27th they continued to increase in weight, gaining 4.17 lb. on the original weight by the end of the winter period. As with the dried grass group, a loss in weight was recorded between the end of March and May 18th, 11.19 lb. being lost during this period. During the summer months on the mountain there was a good live weight increase, and the ewes lost on an average only 1 lb. per head between September 9th and December 15th.

Five ewes died during the period that maize was fed. There were no abortions, and only one lamb was found dead at birth. The ewes gave no trouble in lambing and reared their lambs well. The lambs weighed 6.28 lb. at birth, and were the heaviest when turned up to Nantrhys. They made satisfactory live weight increases during the summer and were a close second in weight to the best group when drafted down on September 9th.

Silage group. These forty-five ewes were put to graze on a seven-acre permanent pasture field which had been mown for ensilage in 1938. They were given two feeds of   lb. per head per day of silage. When keep became scarce on this field they were allowed to graze an adjoining paddock which had been reclaimed from bracken and reseeded in 1934.

These ewes were the lowest in average live weight at the commencement and they continued to lose weight up to the end of March, by which time they had lost an average of 4.58 lb. per head. However, these were the only ewes that did not lose heavily in weight during the period March 27th to May 18th, a slight increase of 0.18 lb. per head being made. This group made a vast improvement in live weight during the summer at Nantrhys, and by September 9th they had gained an average of 15.15 lb. They continued to put on weight from September to December, an increase of 0.36 lb. for this period being recorded on December 15th.

One ewe died during the winter period, but there were no abortions. Out of a total of twenty-three live births, twenty-two lambs were reared, that is, a lambing average of 50 per cent. The lambs were the poorest of all, weighing 5.28 lb. at birth, 14.70 lb. when turned to the mountain, and only 35.87 lb. on September 9th, being practically 10 lb. per head lighter than the best group.

Timothy rows group. As in the previous year, these ewes were turned to graze for two hours per day on the timothy rows and spent the remainder of the day on the adjoining field, which had again been sown with a temporary seeds mixture with a view to wintering. The timothy rows had been mown for hay in 1938, and the aftermath kept, with the result that there was a good deal more bulk and a better quality keep available than during the winter of 1937-38.

The ewes weighed 53.20 lb. per head at the commencement of the experiment, and had made an increase of 3 lb. per head by the middle of February. At the end of February there was a slight decrease in weight, though it was still above the original weight. By March 27th there was a total average live weight increase of 6.30 lb. per head, but from this date to May 18th there was a loss of 10.50 lb. in weight, that is, a loss of 4.2 lb. on the original weight. This was the heaviest group on September 9th, an increase of 12.33 lb. having been made at Nantrhys. There was, however, a loss of 4.83 lb. per head for the period September 9th to December 15th.

These ewes had wintered very satisfactorily and had a good supply of milk and were attentive to their lambs, but of thirty-nine live births, thirty were reared, that is, 68.18 per cent. These lambs were the heaviest at birth, but they did not maintain their initial advantage during the summer on the mountain pasture and weighed only 40.00 lb. when drafted down on September 9th.

Winter Foggage group. These ewes were wintered in the same field and under the same conditions as the corresponding group of the previous year. Apart from a slight drop towards the end of February the ewes increased continuously in weight during the winter period, a live weight increase of 5 lb. per head being obtained by March 27th. A loss in weight of 7.30 lb. occurred between March 27th and May 18th. They did well on the mountain pasture during the summer and reached their maximum average live weight of 55.69 lb. by September 9th, and only a slight decrease of 0.43 lb. was recorded on December 15th.

There were no casualties in this group, and thirty-five lambs were reared without loss, a lambing average of 77.7 per cent. The lambs weighed 6.48 lb. at birth and were the second heaviest at 21.57 lb. when sent to Nantrhys. By September 9th these lambs were the heaviest, having an average weight of 45.62 lb.

Hill Improved pasture group. These ewes were grazed on the same block as the corresponding group of the 1937-38 experiment. During the summer of 1938, eight acres of this area had been ploughed and reseeded on the upturned sod. Nevertheless, they were not so well favoured in this grazing as the group of the previous year in that the severe frosts of December and January killed off, or dried up, the herbage on this exposed area, and they were again severely affected by the hard weather and shortage of keep experienced in April and early May. This fact is reflected in the live weights, since this group lost 4 lb. per head during the first month of the experiment, and they again lost heavily in weight during April and early May. During the summer, however, there was a very marked improvement in their condition, which improvement was more pronounced than in any of the other groups.

There were no casualties in this group and on the whole the ewes gave very little trouble with the lambs. The lambs weighed 5.58 lb. at birth and 17.11 lb. when drafted to Nantrhys in May. They made good progress during the summer and were the third best at 41.66 lb. by September 9th, though approximately 4 lb. per head lighter than the lambs of the maize and winter foggage groups.

Discussion of Results.

General. As previously stated, owing to the difficulty of getting mountain sheep to take to hand feeding, a preliminary period of about a fortnight was utilized to try and sort out a number of ewes that took fairly readily to being hand-fed. When a sufficient number had been obtained they were further drafted out into two lots for feeding with dried grass and maize. In the 1937-38 experiments the heavier sheep seemed to have taken more readily than the others to hand feeding. These ewes probably put on weight during this sorting out period, and it is also probable that some of the other groups may have lost weight during this time. Of the remaining ewes drafted down for wintering a fairly strong lot was selected for grazing on the improved hill pasture. The remainder were sorted out for wintering on the kale, timothy rows and the winter foggage. The two weakest groups were selected for the timothy rows and winter foggage because it was thought that they would be wintering in more sheltered positions and also that they would have a fair amount of keep. Experiments had been carried out in previous years on putting up the timothy rows at different dates for wintering, and during 1937 one half of the area was mown and the other left uncut. To all appearances the unmown part contained plenty of bulk, but chemical analysis proved it to be of very poor feeding value, and this was reflected in poor live weights recorded for this group as compared with the other four lots wintered in the fields.

With regard to the group wintered on the improved hill pasture it might be stated that the only hill available for this experiment was probably too exposed and bleak from one point of view. On the other hand this block is typical of the bulk of the land that has been improved by the Cahn Hill Improvement Scheme, and it was necessary to test out the value of this type of improved land for wintering mountain sheep. Probably one would be right in saying that this type of land would be most useful if run in areas large enough to allow access to different aspects for shelter purposes during the winter.

During the 1938-39 experiment the same remarks apply as regards the procedure adopted for sorting out sheep that showed a partiality for hand feeding. The greatest difficulty was with the silage fed group, and these ewes lost appreciably in weight during the winter period of the experiment.

The experiment was designed to test out various methods of foodstuffs for the wintering of hill ewes, at an altitude ranging from 900 to 1,100 ft. above sea level, and the summering of the same sheep on an unenclosed mountain sheep walk ranging from 1,500 to 2,000 ft. During the summer months the experimental sheep were run under exactly the same conditions as the others on the sheep walk which extends in all to about 2,200 acres.

Owing to practical difficulties it was not possible to weigh these experimental sheep at Nantrhys more than twice during the period under review. The experiment, therefore, cannot in any sense be described as strictly critical and scientific because of the number of practical factors that had to be taken into consideration, but it can be considered as a preliminary investigation.

On the adjoining hill farms in the district it is the custom about the middle of December to bring down to the more sheltered fields all the younger ewes, leaving only the stronger ewes and wethers on the mountain throughout the winter. Therefore, the material to be used was necessarily rather varied in character, and on the whole in a lean condition. This fact again was reflected not only in the weight of the ewes, but also in the number of successful services by the ram, and in the number of live birrths. To a lowland farmer the lambing percentages would be extremely low, and even to a hill farmer would seem poor. As already stated, the ewes were the poorer ones on the mountain, the lambing percentage of which if left on the hill all the winter would be very much lower and the casualties would no doubt have been high, especially if heavy snowstorms had been experienced.

There are two lots of ewes that have done badly and are not strictly comparable, namely, the group grazing on the timothy rows during the winter of 1937-38 and the silage fed group of 1938-39. It must also be borne in mind that the pasture on the improved hill was in a very exposed situation, and the sheep suffered badly during the north and north-easterly gales. Further, scouring when first turned on the pastures retarded the rate of progress of the ewes on the winter foggage in 1937-38. The cold dry weather experienced during April and early May, 1939, reduced the number of lambs reared and their live weight increases as compared with those of the 1937-38 groups. The loss in weight of the ewes during this period was greater in every case than in the corresponding period of the previous year.

Lambing results. In the main it may be said that the lambs that were heaviest at birth kept their lead right up to weaning time. This seems to imply that the condition of the ewe during pregnancy not only determines the weight of the lamb at birth, but also, other things being equal, the rate of growth of the lamb for a certain period afterwards. In most of the groups this period could be said to last up to weaning time, though the lambs from the timothy row group of ewes in the 1938-39 experiment for some reason did not keep up their lead. Furthermore, the food on which the ewes have been wintered does not seem adversely to affect the rate of growth of the lamb when turned to graze on the mountain pasture. It is a popular belief among hill farmers that lambs reared by hand-fed ewes, especially those fed with maize, will not thrive as well as lambs reared by ewes wintered on pasturage, but the results of the experiment seem to disprove this theory. In both years the lambs from the maize fed group have given the second biggest live weight increase from birth to weaning time. In both years it is the winter foggage group that has given the highest and most consistent live weight increases from birth to weaning time. The lambs from the ewes fed on dried grass have also done well. On the other hand, the kale group of lambs did not do so well, either when grazing with their dams on the improved hill before being sent to Nantrhys, or on the mountain pasture during the summer. This seems to suggest that the loss of the high protein food caused a setback which was not so marked in any of the other groups. The lambs from the hill improved pasture group did not do so well the first year as in 1938-39, when they gave the highest live weight increase for the period on the mountain. It is difficult to make any strict comparison between the lambs from the ewes grazing on the timothy rows because in the first year, due to the dams grazing on the old foggage for the first weeks of the experiment, the lambs were poor and weak. In the second year, with a much better quality foggage, the lambs were the heaviest at birth, but they did not keep up this lead afterwards. The lambs from the silage fed group will not bear strict comparison with the others, because the ewes at lambing time were in very poor condition and the lambs remained the lightest throughout the experiment.

Excluding the silage group of 1938-39 the only ewes to have lost weight during the wintering period in both years are those grazed on the hill improved pasture. The biggest gains in live weight in 1937-38 were made by the maize and dried grass groups. In 1938-39, with half the previous year's rations, these two groups did not put on quite half the live weight increase of 1937-38 during this period. The most consistent group in both years was the winter foggage, while in 1937-38 the timothy rows group of ewes gave poor live weight increases, yet in 1938-39 their increase in weight was higher than any of the others.

During the period from the end of March to the middle of May one would not normally expect any live weight increase, because it is during this time the lambs are dropped and there is very little pasture available. In the lambing period of 1937-38 the only groups to lose weight seriously were the dried grass and maize, and the hill improved ewes were the only ones to make any substantial gains. It must be borne in mind, however, that the weather during this period in 1938-39 was abnormally hard, the cold east wind causing serious damage to the pastures. With the exception of the silage group, severe losses in weight were recorded with up to 11.35 lb. per head being lost by the maize group of ewes.

In both years substantial live weight increases have been made by all groups during the summer at Nantrhys. Excluding the abnormal silage group of 1938-39 and the timothy rows of 1937-38, the biggest live weight increases from the middle of May to September have been made by the hill improved group. In the first year the maize and dried grass groups with heavy rations of their respective feeds in the pre-lambing period, did not do so well on the mountain, especially the dried grass ewes, but with the reduced ration in 1938-39 these ewes did much better The timothy rows ewes of both years did well, and the silage fed group were exceptional in their improvement, but this was probably due to their poor condition when turned back to the mountain.

During the post-weaning period, that is, from early September to the middle of December, the dried grass group lost more weight than any of the others. Slight increases in live weights were made in both years by the hill improved pasture ewes, and though the ewes from the winter foggage area made a slight increase in weight in 1937-38, a loss in weight was recorded in 1938-39; while the ewes from the timothy rows gained in weight the first year during the post-weaning period, a substantial loss was made in 1938-39.

Summary.

(1) Generally speaking, it will be seen from these wintering experiments that the heaviest lambs at birth maintained the lead right up to weaning time.

(2) The hand feeding of the ewes does not adversely affect the subsequent growth and thriftiness of the lambs.

(3) Lambs from very weak ewes at lambing time do not make up for the poor condition at birth during the suckling period, even though their dams improve more in condition during this period than the ewes from any of the other groups.

(4) The wintering of ewes with different foodstuffs does affect their ability to thrive when turned back to the mountain for the summer.

(5) The feeding of maize during the winter period increases the mortality of the ewes during the feeding time.

(6) The biggest live weight increase during the summer on the mountain was made in both years by ewes wintered on improved hill pastures, and this was the only group to increase in weight in both years during the period September to December.

(7) The ewes wintered on dried grass lost more weight in the post-weaning period (September to December) than any of the others.

(8) The timothy rows group of ewes when wintered too well, as in 1938-39, did not do so well on the mountain from May to September, and lost weight heavily from September to December, which seems to suggest that ewes that are in too good a condition during the winter period do not maintain the same degree of improvement when turned to graze on the mountain during the summer and autumn.

(9) The ewes fed on winter foggage gave the most consistent live weight increases throughout the period of the experiment in both years. These ewes also gave the highest number of lambs reared per live birth, and the average live weight increases of these lambs from birth to weaning was higher than any of the others.

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References.

1. GRIFFITH, MOSES (1935). A preliminary report on the work of the Cahn Hill Improvement Scheme. *Welsh J. Agric.* Vol. II. pp. 140-7.
2. GRIFFITH, MOSES, and HUTTON, P. M. G.(1935). The wintering of sheep on temporary grasses. *Welsh J. Agric.* Vol. II. pp. 121-5.
3. ———————————— (1936). The wintering of sheep on temporary grasses. *Welsh J. Agric.* Vol. 12. pp. 126-30.
4. GRIFFITH, MOSES (1937). The Cahn Hill Improvement Scheme. *Welsh J. Agric.* Vol. 13. pp. 211-23.
5. STAPLEDON, R. G. (1935). *The Land Now and To-morrow.* Faber and Faber, London.
6. STAPLEDON, R. G., DAVIES, WM., ROBINSON, G. W., and ROBERTS, E. (1936). *A Survey of the Agricultural and Waste Lands of Wales.* Edited for the Cahn Hill Improvement Scheme by R. G. Stapledon. Faber and Faber, London.

EXPERIMENT ON THE ERADICATION OF BRACKEN BY SUMMER PLOUGHING.

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The writer did not intend publishing the results of these experiments until more extensive investigations had been carried out, but the data are here presented in view of their bearing upon increased food production at the present time.

The results of these experiments indicate that ploughable bracken-infested land can be utilized immediately for crop production, especially potatoes, and by ploughing the bracken in, as suggested, in July and early August, the bracken can be reduced to a negligible extent, thus preparing the way for a rotation of crops on this type of land.

Monument Hill, Knighton.

It occurred to the writer that it would be interesting to see what would be the result of ploughing in bracken during the summer, and in July, 1935, when the Caterpillar tractor, the heavy Junotrac plough and other implements were working on bracken-infested land at Knighton, a heavy crop of bracken was ploughed in and the land left fallow for the rest of the season. The following year there was very little growth of bracken on this July ploughed land as compared with adjoining blocks of similar land that had been ploughed during the winter months and seeded during the following May. Up to the present time this reduction in the bracken infestation has been maintained.

Pwllpeiran Hill.

During the summer of 1938 this theory of bracken eradication by summer ploughing was further tested. A small area of bracken-infested land on the Pwllpeiran Hill was selected for ploughing, leaving a strip of similar land unploughed as a control area. When the bracken started growing the following year there was a tremendous difference in the ploughed and unploughed plots. Whereas in a few weeks the unploughed land was soon completely covered with bracken, only isolated and weakly plants succeeded in making any growth on the ploughed area. The same remarks apply to this year's growth on both plots.

Llety Hill, Cilcain, Flintshire.

The owner of this farm, Captain Norman Roberts, purchased a Ferguson tractor with a single furrow heavy digger plough, which was capable of ploughing in a heavy growth of bracken or heather. An area of very strong growing bracken with an average density of 48 plants per square yard with an average height of 39 inches was ploughed in during the third week of July, 1939. When this land was inspected during the last week in July, 1940, there were only a few isolated and weakly plants growing with a density of one plant per two square yards with an average height of 7 inches.

Hengwm Hill, Knighton.

This block of hill land was covered with very dense bracken and practically useless for grazing during the summer months, owing to the danger of maggots. Mr. Heckstall Smith, the new owner, decided to plough as much as possible of this hill during the summer of 1939. The ploughing was let out on contract to Mr. Sandy Jones, of Clarach, with his Caterpillar tractor and heavy Ransome's Junotrac plough. The bracken on this area had an average density of 42 plants per square yard, with an average height of 43 inches. The Junotrac ploughed this heavy bracken in quite successfully, the work being done during the early part of August. When the land was inspected during the third week of July, 1940, there were only a few isolated bracken fronds to be seen growing on the ploughed part, with an average density of 1.5 plants per square yard and having an average height of 8 inches. The land was sown with various crops. Turnips and buckwheat had been sown in July, while potatoes had been planted in May with only artificial manures. This potato crop was a very promising one and the haulms had already completely covered the ground.

Black Hill, Mynachty, Knighton.

This hill is the property of Sir Robert Green Price, Bt., and he successfully tackled a block of land similar to the Hengwm Hill in 1939, but containing more gorse and heather and less bracken. This land was re-seeded the first year and was transformed into a good sward in one season, the sward containing a high percentage of the better grasses and wild white clover. The bracken on his hill had a density of 40 plants of an average height of 30 inches per square yard. The ploughing was carried out by the same man and the same outfit as on the Hengwm Hill, but the ploughing was not done until late August and early September. The killing of the bracken has not been quite so successful, and of all the blocks ploughed during the summer this hill had the highest bracken density, that is, 2.2 plants per square yard. The area ploughed was approximately 50 acres and it was re-seeded during June, 1940.

Conclusions.

From the results of these five experiments there are definite indications that when land very heavily infested with bracken is ploughed during the summer months, especially during July and early August, the bracken is so reduced as to become negligible and if the land is cropped and cultivated during the following year the bracken is practically killed off. On land that is fairly easily ploughable in contradistinction to the previous methods of eradication, that is, by cutting twice a year for three or four years, this method of eradication by summer ploughing is in the long run much more effective and cheaper, inasmuch as it is possible to re-seed either straight away or in the second year after taking a crop of rape and/or turnips. Furthermore, it is better not to plough the second year, but to disc heavily prior to sowing, thus saving the cost of the second ploughing. On one area in this experiment an excellent crop of potatoes has been grown in the first year.

Though these results are not critical enough to state the exact time to plough so as to completely kill off the bracken, the indications are that the land should be ploughed during July and early August.

It should be emphasized that a heavy digger type of plough is the ideal for this work. There is generally plenty of depth of soil under dense bracken and the ploughing should be deep, laying as flat a furrow as possible so as to bury all growth.

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TABLE I.

Bracken counts per square yard and height in inches during third week in July, 1940.
(Average of 10 quadrats per area.)

Centre	*Date of ploughing*	*Ploughed area*		*Unploughed area*	
		No. of plants per square yard	*Height in inches*	*No. of plants per square yard*	*Height in inches*
Monument Hill, Knighton ..	Early July, 1935.	1.50	9	35	40
Pwllpeiran Hill	Middle of August, 1938.	2.00	8	29	36
Llety Hill, Cilcain	Third week in July, 1939.	0.50	7	48	39
Hengwm Hill, Knighton	Early August, 1939.	1.50	8	43	43
Black Hill, Knighton	Late August, 1939.	2.20	8	40	40

THE RESAZURIN TEST.

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Some preliminary work carried out by the writers during 1938 showed that the reduction of resazurin to purple pink, pink or white gave fairly good statistical correlations with methylene blue reduction (Davies *et al.* 1939). It was realised that the test is particularly useful for the detection of poor quality milk at country creameries. Regular weekly series of samples from supplier's milk arriving at two local creameries, together with daily series of tuberculin tested and accredited milk have therefore been examined by means of the methylene blue and resazurin tests over a twelve months' period. The results of investigations on certain practical points in connection with the application of the test are also reported. A review of investigations on the test up to 1938 is given in our preliminary article, whilst Davies (1940) has reviewed more recent work.

Comparison of resazurin and methylene blue reduction.

The results of the grading of 2,408 "winter" samples and 1,551 "summer" samples by means of the two reduction tests are given in Tables I and II. Ten ml. of milk was used for each test, the tubes being incubated in water baths at 37°—38°C., and inverted every half hour. One ml. of a 0.005 per cent resazurin (Eastman) solution was added to each 10 ml. of milk, thus giving a concentration of 1 in 220,000. The 0.05 per cent stock solution was momentarily autoclaved and kept in a refrigerator at 4°—5°C., the 0.005 per cent bench solution being made up daily with sterile glass distilled water. The solution remained free from contamination as long as these precautions were observed.

It will be seen that most of the samples reducing resazurin to the white stage within 1 hour, reduced methylene blue within 1 hour during the summer period and within 2½ hours during winter.

Approximately 95 per cent of the samples that reduced resazurin to the pink stage reduced methylene blue within 4½ or 5½ hours during summer and winter respectively. Of the samples reduced to the purple pink stage only 51 per cent failed on the methylene blue test during winter and 57 per cent during summer. Of 2,480 samples that did not reduce resazurin within one hour during the year, 16 per cent were unsatisfactory on the methylene blue test.

Bearing these results in mind it is suggested therefore that for the preliminary grading of supplier's milk on arrival at factories, milk reducing resazurin to pink or white within one hour can be considered unsatisfactory, and further examinations carried out on these supplies. Of the 3,959 samples examined, 17 per cent reduced resazurin to the pink or white stages within one hour compared with 37 per cent which reduced methylene blue within 4½ or 5½ hours, so that the suggested standard for preliminary advisory work is quite lenient. Milk reducing to purple pink only, within one hour can be considered slightly unsatisfactory and it will be generally found that the methods of production at the farm or transportation to the factory in such cases need some improvement.

TABLE I.

Comparison of resazurin and methylene blue reduction " Winter "—(November—April).

	Methylene blue reduction at 37°C.					
Resazurin reduction in 1 hr. at 37°C.	*Over 8½ hrs.*	*6-8½ hrs.*	*3-5½ hrs.*	*1-2½ hrs.*	*½ hr.*	*Total samples*
Blue	719	758	202	27	1	1,707
Purple pink	73	151	135	93	2	454
Pink	2	7	11	102	5	127
White	0	3	1	27	89	120
Total samples	794	919	349	249	97	2,408

TABLE II.

Comparison of resazurin and methylene blue reduction " Summer "—(May—October).

	Methylene blue reduction at 37°C.					
Rezasurin reduction in 1 hr. at 37°C.	*Over 7½ hrs.*	*5-7½*	*3-4½*	*1-2½*	*½*	*Total*
Blue	279	323	140	29	2	773
Purple pink	30	110	90	104	3	337
Pink	1	5	12	125	14	157
White	0	0	1	39	244	284
Total samples	310	438	243	297	263	1,551

In applying the test to grade milk after one hour's incubation at 37°C. we assume that unreduced samples (still blue) are of satisfactory quality, those purple pink—doubtful, pink—poor and white—very poor. Samples reducing as far as the purple pink stage only, may or may not be unsatisfactory on methylene blue reduction, but when all the samples reducing to purple pink, pink or white were correlated with methylene blue reduction a correlation coefficient (r) of +0.658 was obtained. Yule's coefficient of association (Q) for the results given in Table III is 0.886. These statistical data indicate fairly good agreement on this basis of classification of satisfactory and unsatisfactory samples. Samples which reduced methylene blue within 4½ hours in "summer" and 5½ hours in "winter" are considered to have failed to attain a satisfactory standard.

Eighty-one per cent passed or failed both tests, whilst the anomalous results were fairly equally divided between the passed resazurin, failed methylene blue group and the failed resazurin passed methylene blue group. Davis and Theil (1939) found that 90 per cent of the samples examined by them passed or failed both tests, when resazurin grading was carried out in 30 minutes.

TABLE III.

	Passed Methylene Blue Test		*Failed Methylene Blue Test*		*Total samples*	
	No.	%	*No.*	%	*No.*	%
Passed resazurin test	2,088	53	400	10	2,488	63
Failed resazurin test	364	9	1,088	28	1,452	37
Total samples	2,452	62	1,488	38	3,940	100

When the results of the resazurin and methylene blue tests are arranged according to sampling season (Table IV) it will be observed that relatively more samples failed methylene blue during summer (June—August) whilst more failed resazurin during autumn and winter (October—March). It is suggested that this may be due to the fact that during the colder autumn and winter months bacterial reducing action is not so pronounced as in the warm summer months and that the activity of other reducing factors such as that of leucocytes is comparatively more effective. It is well known that resazurin is much more sensitive to the presence of leucocytes than methylene blue. Furthermore it has been observed that autumn and winter milk contains more late lactation milk and is characterised by a higher leucocyte content particularly around the calving period.

TABLE IV.

Month	*No. of samples examined*	*Per cent samples reducing*		*Ratio Resazurin failures, /M.B. failures*
		Methylene blue within :—	*Resazurin within 1 hour*	
" Winter "		*5½ hours*		
Nov.	457	42	36	0.81
Dec.	426	26	23	0.88
Jan.	319	3	18	5.70
Feb.	472	16	19	1.24
March	482	29	30	1.01
April	428	42	41	0.97
" Summer "		*4½ hours*		
May	404	46	57	1.30
June	124	55	43	0.78
July	341	50	37	0.74
Aug.	297	88	72	0.82
Sept.	98	44	39	0.88
Oct.	388	33	34	1.06
Total	4,236	37	36	0.97

Comparison of resazurin reduction and keeping quality.

The comparison of resazurin reduction within one hour at 37°C and keeping quality of the milk as obtained by means of methylene blue reduction at 15°C (60°F) shows a fairly good correlation (Table V). Samples reducing to white at 37°C. had keeping qualities under 12 hours from the time of setting up the tests. Similarly all the samples reducing to the pink stage had poor keeping qualities. Of the samples reducing to purple pink 84 per cent had keeping qualities under 36 hours. On the other hand the keeping quality of the samples which did not reduce resazurin varied considerably.

TABLE V.

Reduction of Res. in 1 hour at 37°C.	*Methylene blue reduction at 60°F.*					*Total Samples*
	Within 12 hrs.	*13-24 hrs.*	*25-36 hrs.*	*37-48 hrs.*	*49-60 hrs.*	
Blue	1	35	27	28	3	94
Purple pink	3	23	20	7	2	55
Pink	4	4	0	0	0	8
White	11	0	0	0	0	11
Total	19	62	47	35	5	168

Comparison of resazurin reduction and results of microscopical examination.

A series of factory and designated milk samples taken during December—March were examined on arrival at the laboratory by means of the methylene blue and resazurin reduction tests as well as by the Breed direct microscopic test; bacterial clump counts and cell counts being made. The results given in Table VI are classified according to whether the samples reduced resazurin to purple pink or further within one hour and methylene blue within 5½ hours. Samples failing both tests had very high bacterial clump counts and cell counts. Samples failing on methylene blue alone, had very low leucocyte counts and a fairly high mean bacterial clump count. This group contained many border line cases. The mean methylene blue reduction time was 4¼ hours; actually a large proportion of the samples had methylene blue reductions of 4½ to 5 hours and bacterial clump counts of 150,000 to 250,000. Furthermore the organisms present may have been in a dormant state and did not show much reducing activity within the first hour, but may have become active in 4 — 5 hours. Samples failing on resazurin alone were characterised by a very low bacterial count and an excessively high leucocyte content. This (presumptively) demonstrates the marked influence of leucocytes on resazurin reduction. Samples passing both tests had very low bacterial counts and leucocyte counts below the mean for the whole series.

TABLE VI.

	Samples		*Mean reduction times and microscopic counts*				
			M.B. reduction (Hrs.)	*Resazurin reduction*		*Bacterial clump counts*	*Leucocyte counts*
	No.	%		*Purple pink (Hrs.)*	*Pink (Hrs.)*		
Failed both tests	184	13	2.18	0.66	.143	977,000	646,000
Passed res., failed meth. blue	104	7	4.15	2.02	3.32	155,000	245,000
Failed res., passed meth. blue	149	11	7.93	0.83	3.16	21,000	955,000
Passed both tests	978	69	8.51	3.17	6.07	11,000	468,000
TOTALS	1,415	100	7.31	2.51	5.05	25,000	501,000

The results of the microscopical examination of 287 autumn samples and 213 winter samples *which reduced resazurin within one hour* are analysed in Table VII. Of the 500 samples examined, 65 per cent had high bacterial clump counts of 500,000 and over per ml whilst an additional 32 per cent which had low bacterial counts had high leucocyte counts. Only 3 per cent had both low bacterial and leucocyte counts. The autumn and winter resazurin test failures differed considerably, more especially in that only 17 per cent of the autumn samples had low bacterial counts and high leucocyte counts, whereas as many as 53 per cent of the winter samples were placed in this group. Hence this is further a priori evidence of the significance of leucocyte activity during the winter months.

TABLE VII.

Bacterial and leucocyte counts	*Autumn, Sept.-Nov.*		*Winter, Dec.-Feb.*		*Total samples*	
	No.	%	*No.*	%	*No.*	%
*High bacterial clump counts and high leucocyte counts	164	57	58	27	222	45
High bacterial clump counts and low leucocyte counts......	74	26	28	13	102	20
Low bacterial clump counts and high leucocyte counts	49	17	113	53	162	32
†Low bacterial clump counts and low leucocyte counts	0	0	14	7	14	3
TOTALS	287	100	213	100	500	100

*High bacterial clump counts and leucocyte counts :—500,000 and over per ml.
†Low counts :—under 500,000 per ml.

Cellular content of milk and reducing activity.

The problem of the sanitary significance of the presence of leucocytes in fresh milk attracted much attention 25 to 30 years ago, whilst their relation to the reduction of methylene blue and resazurin has recently been under consideration. The evidence available indicates that during the transformation of the lymph into milk, the amoeboid leucocytes migrate through the tissues and enter the alveoli with the milk. The number of these cells varies considerably in normal healthy udder milk ; estimates made by recent investigations ranging from 50,000 to 1,000,000 per ml., though the majority agree that milk from absolutely normal udders (free from mastitis, colostrum, end of lactation or retained milk) generally contains less that 100,000. Infection of the udder with mastitis streptococci or staphylococci or even with Brucella abortus causes increased numbers to enter the milk. Other physiological factors such as retention of milk, drying off and first milking after calving also produce an increased cell content. The relative leucocyte content of different types of milk is given in Table VIII. The normal udder milk samples were drawn aseptically from 30 cows of varying age and during different times during the lactation period except immediately prior to or after calving. None of the samples showed any macroscopic evidence of mastistis and no organisms were detected on microscopical examination. There was evidence of the presence of chronic or sub-clinical mastitis in some of the cows so that the rather high cell counts obtained were not unexpected. The bulk herd milk samples were from designated and factory milk taken during December—March which approximately covers the calving period in this district. Even then the cell content of this milk was slightly lower than that for udder milk. The colostrum which was taken during the first five milkings after calving contained a much higher leucocyte content, generally ranging from one to fifty million per ml. The end of lactation milk was taken during the last two weeks of the drying off period, whilst the mastitis infected samples all contained millions of mastitis streptococci and were very abormal in appearance. The cell counts were too high to estimate with any degree of accuracy but 80 per cent showed the presence of over 5,000,000 leucocytes per ml.

TABLE VIII.

	Normal udder milk	*Bulk herd milk*	*Colostrum*	*End of lactation milk*	*Acute mastitis milk*
No. of samples	232	1,415	20	25	20
Cell count	Percentage distribution.				
Under 50,000	9	2	0	0	0
50,000—250,000	35	24	0	0	0
250,000—1,000,000	35	56	25	0	5
1,000,000—5,000,000	17	17	45	68	15
5,000,000—50,000,000	4	1	30	32	35
50,000,000—250,000,000	0	0	0	0	40
250,000,000—1,000,000,000	0	0	0	0	5

Physiologically or pathologically abnormal milk with very high leucocyte counts reduced both resazurin and methylene blue quickly (Table IX). Of the presumably normal udder milk samples, 29 per cent reduced methylene blue within 5½ hours. It is interesting to note that a significant proportion of the bulk herd milk samples with a very low bacterial content reduced resazurin within one hour and that 4 per cent of these samples also reduced methylene blue. The results for bulk herd milk and udder milk are also analysed in Tables X and XI. It will be seen that most of the samples in both types of milk which have over 2,000,000 leucocytes per ml. reduced resazurin whereas the reduction of methylene blue was rather variable. The proportion of samples reducing resazurin increased with increasing leucocyte content. The same tendency was observed in the case of methylene blue reduction with udder milk but this was not so with bulk herd milk.

The above results thus show that milk containing a high leucocyte content reduces resazurin quickly and has a much less marked and more variable effect on methylene blue reduction. Ramsdell et al (1935) Barrett et al. (1937), Keenan et al. (1937), Frayer (1938), Nelson and Foltz (1938) and Russell, Palmer-Jones and Moir (1939) have investigated and discussed the influence of leucocytes on resazurin reduction. These workers have been able to demonstrate a definite though rather uneven relationship between resazurin reduction and the leucocyte content of milk samples. Skar (1913), Bahr (1914), Barthel (1917), Thornton and Hastings (1930), Bryan and Trout (1935), Devereaux and Bryan (1936), Malcolm and Leitch (1936) Nichols and Edwards (1936) and McClemont and Davis (1939) have investigated the action of milk high in leucocyte content on methylene blue reduction. Most of them conclude that milk containing numerous leucocytes reduced methylene blue sooner than one poor in leucocytes, but that it is improbable that leucocytes play a major role in the methylene blue reduction of normal bulk herd milk, though they may do so in abnormal udder milk samples. Mastitis milk with very high leucocyte counts has been observed to reduce methylene blue rapidly in the absence of oxygen. This may be easily re-oxidised by the admission of air on inversion of the tubes. The writers found that mastitis infected milk occasionally reduced triple strength methylene blue (1/130,000 concentration in milk) within a few minutes of setting up the test. On inversion of the tubes however the colour usually returned and the final reduction was often longer than 7 hours.

TABLE IX.

Type of Milk	No. of samples	Mean leucocyte count	Per cent samples reducing	
			Resazurin within one hour	Methylene blue within 5½ hrs.
Bulk herd milk samples with bacterial clump counts under 25,000 per ml.	879	470,000	14	4
Udder milk (quarter samples) with bacterial clump counts under 25,000 per ml.	372	748,000	29	11
End of lactation milk	25	3,310,000	100	70
Colostrum	20	3,340,000	90	90
Mastitis milk	20	25,000,000	100	95

TABLE X.

Bulk herd samples with bacterial clump counts under 25,000 per ml.

Cell count per ml.	*No. of samples*	%	*Reducing res. within 1 hr.*		*Reducing methylene blue within 5½ hrs.*	
			No.	%	*No.*	%
Under 5,000	17	2	0	0	2	12
50,000—100,000	68	8	7	10	6	9
100,001—250,000	197	22	11	6	8	4
250,001—500,000	256	29	17	7	7	3
500,001—1,000,000	216	25	30	14	11	5
1,000,001—2,000,000	102	12	43	42	4	4
Over 2,000,000	23	2	18	78	0	0
TOTAL SAMPLES	879	100	126	14	38	4

TABLE XI.

Normal udder quarter samples with bacterial clump counts under 25,000 per ml.

Cell count per ml.	*No. of samples*	%	*Samples reducing Resazurin within 1 hr.*		*Samples reducing M.B. within 5½ hrs.*	
			No.	%	*No.*	%
Under 50,000	20	9	0	0	0	0
50,000—100,000	29	12	2	7	0	0
100,001—250,000	53	23	3	6	0	0
250,001—500,000	41	18	5	12	2	5
500,001—1,000,000	40	17	13	32	3	7
1,000,001—2,000,000	19	8	14	74	7	37
Over 2,000,000	30	13	30	100	14	47
TOTALS	232	100	67	29	26	11

Effect of cold storage of milk on resazurin reduction.

Frayer (1930) and Wilson et al (1935) found that the methylene blue reduction of milk iced for 18 — 24 hours was 5 —10 minutes longer than that of control samples tested immediately on arrival at the laboratory. In order to facilitate laboratory routine it is generally advisable to place morning's milk samples in a refrigerator at 32° — 40°F. between 6 p.m. and 10 a.m. the following morning when the reduction tests are set up. The results given in Table XII show that when 62 six ounce bottles of milk were placed in a refrigerator run at 5°C (41°F) the temperature of the milk took several hours to drop to 10°C. and was still at 6°C. the following morning. Partial refrigeration overnight in this case resulted in a shortening of resazurin reduction by 16 minutes for the purple pink stage and 20 minutes for the pink stage. When batches of 60 two ounce samples were placed in the refrigerator run at slightly lower temperatures so that the milk was brought down to 0° — 2°C. within an hour or so, icing for 18 hours increased the mean resazurin reduction times to purple pink and pink by 3 to 14 minutes. This increase can not be considered to have any significant effect on the reduction times and icing overnight can thus be conveniently utilised for storing mornings milk samples.

TABLE XII.

(Times in hours and minutes.)

Season and Temp. on Sampling	*No. of samples*	*Temp. of milk in refrig.*	*Mean resazurin reduction times*					
			Purple pink			*Pink*		
			Before icing	*After icing*	*Mean diff'nce*	*Before icing*	*After icing*	*Mean diff'nce*
Sept. 58 °F.	62	10° to 6°C.	1 : 48	1 : 32	—0 : 16	2 : 38	2 : 18	—0 : 20
Nov. 55 °F.	60	6° to 2 °C.	1 : 21	1 : 28	+0 : 07	2 : 13	2 : 33	+0 : 11
Dec. 50 °F.	60	3° to 0 °C.	2 : 58	3 : 10	+0 : 12	6 : 00	6 : 12	+0 : 12
Jan. 51 °F.	60	2° to 1 °C.	2 : 37	2 : 51	+0 : 14	4 : 55	5 : 13	+0 : 18
Jan. 49 °F.	60	2° to 0 °C.	3 : 03	3 : 19	+0 : 16	5 : 16	5 : 19	+0 : 03

Effect of half hourly inversion of tubes.

The main feature of the modification of the methylene blue test recommended by Wilson et al. (1935) is the inversion of the tubes in the water bath at half hourly intervals, which results in a considerable diminution in the reduction times of good quality raw milk. Some recent work at this laboratory (Williams, Davies and Thomas 1939) showed that inversion resulted in very little difference in the reduction time of poor quality milk reducing within 5½ hours, but a marked decrease in reduction time was obtained with good quality milk. The results of half hourly inversion of resazurin tubes (Table XIII) show a similar trend. Good quality milk reduced to purple pink, pink and white much quicker when the tubes were inverted. It will be observed however that in the case of reductions recorded within one hour inversion actually increased the reduction time by 4 to 7 minutes, due presumably to the incorporation of oxygen. It is therefore recommended that the tubes should not be inverted half hourly when milk is graded by resazurin reduction in one hour.

TABLE XIII.

	Tubes not inverted			*Tubes inverted half hourly (Mean reduction times)*	*Difference due to inversion*
	Class intervals reduction times	*No. of samples*	*Mean reduction times*		
Reduction to purple pink	0:15—1:00	106	0:33	0:37	+0:04
	1:30—2:30	82	1:54	1:55	+0:01
	3:00—4:00	38	3:20	2:57	—0:23
	Over 4 hours	14	5:30	4:11	—1:19
	TOTALS	240	1:44	1:38	—0:06
Reduction to pink	0:15—1:00	58	0:33	0:39	+0:06
	1:30—2:30	30	2:00	1:48	—0:12
	3:00—4:00	38	3:25	2:50	—0:35
	4:30—5:30	24	4:50	4:16	—0:34
	6:00—7:00	39	6:34	5:14	—1:20
	Over 7 hours	51	8:15	0:06	—2:09
	TOTALS	240	4:14	3:24	—0:50
Reduction to white	0:15—1:00	39	0:43	0:50	+0:07
	1:30—2:30	23	2:06	2:16	+0:10
	3:00—4:00	22	3:41	4:27	+0:46
	4:30—5:30	23	5:06	4:49	—0:17
	6:00—7:00	37	6:27	5:44	—0:43
	7:30—8:30	31	7:58	5:47	—2:11
	9:00—10:00	30	9:37	7:32	—2:05
	Over 10 hours	35	11:36	7:54	—3:42
	TOTALS	240	6:04	4:57	—1:07

Effect of direct sunlight on resazurin and methylene blue reduction.

The effect of exposing tubes of milk and oxidation reduction indicators to direct sunlight during winter and spring is shown in Table XIV. The photochemical effect is considerable in the case of methylene blue; samples which took 66 hours in the dark at atmospheric temperature being reduced on the average in 25 minutes in the sun, some samples being reduced within 10 minutes. The reduction of resazurin to purple pink and pink was still more marked, reduction to pink taking place within one minute during spring. The reduction from pink to white was much slower than methylene blue reduction. It is evident therefore that the irre-

TABLE XIV.

Reduction times in hours and minutes.

Period of examination	No. of samples	Temp. of milk in sun	Methylene blue reduction			Resazurin reduction								
						Purple pink			Pink			White		
			In Sun		Dark	Sun		Dark	Sun		Dark	Sun		Dark
			Maximum	Mean	Mean	Maximum	Mean	Mean	Maximum	Mean	Mean	Maximum	Mean	Mean
Nov.—Jan.	17	54° to 56°F	0:10	0:25	66:00	0:02	0:08	42:00	0:05	0:17	63:00	1:00	2:32	77:00
April—May	19	64° to 73°F	0:15	0:36	30:00	0:01	0:01	14:00	0:01	0:02	23:00	0:30	2:41	31:00

versible chemical change of resazurin (blue) to resorufin (pink) is strongly affected by sunlight while the reversible oxidation—reduction of resorufin to hydroresorufin (colourless) is only slightly affected.

These results show that the exposure of resazurin tubes to direct sunlight for periods of one minute during the setting up of the test may have a very significant effect on the grading.

Examination of tubes in daylight and artificial light

Readings taken in artificial light (dark room with shaded Osram 75w. electric bulb 6 feet from water bath) gave purple pink reduction times approximately one hour shorter, and pink reduction times half an hour shorter than those obtained in daylight in front of a window facing N.W. (Table XV) Comparator readings gave similar results, the lilac to purple pink colours being detected quicker in artificial light, whilst this phenomenon was not so marked with the pink colour (Table XVI).

It is advisable therefore to read all results either in roughly standardised daylight such as a bench in front of a north west window or under artificial light conditions which could be better controlled.

TABLE XV.

Comparison of examination of reduction in daylight and artificial light.

Reduction to	*No. of samples*	*Mean reduction times*		*Difference*
		In daylight	*In artificial light*	
Purple pink	240	3 : 11	2 : 00	—1 : 11
Pink	240	5 : 45	5 : 06	—0 : 39

TABLE XVI.

Lovibond comparator readings in daylight and artificial light.

Comparator readings in daylight		*Per cent readings in artificial light*			*Total number of readings*
Disc	*Colour*	*Same as daylight*	*+1 disc*	*+2 discs*	
1	Blue	23	72	5	137
2	Lilac	31	67	2	168
3	Mauve	43	57	0	176
4	Purple pink	57	42	1	193
5	Pink	79	21	0	145
6	Vivid pink	100	0	0	181
TOTAL		57	42	1	1,000

Different type and concentrations of resazurin.

Three brands of resazurin dye made by different manufacturers have been compared. Brand A was unsuitable for the test the colour on adding to milk being purple pink to pink and not blue. Brand B. manufactured by the Eastman Kodak Co., Rochester, N.Y. underwent the normal sequence of colour charges and has been used throughout this work. The Lovibond experimental comparator has been designed for use with this brand. Brand C. manufactured by the National Aniline and Chemical Co., Inc., New York, N.Y., is certified for use as an indicator of reduction in milk by the American Commission on Standardization of Biological Stains. The batch examined by us gave better tinctorial properties in milk than the other brands. A comparison of the reduction times obtained at room temperatures with Brands B and C showed no significant difference.

Brand B was generally used as a concentration in milk of 1/220,000, but for examination of the reduction of abnormal samples such as colostrum and acute mastitis milk as well as cream, triple strength solution (1/70,000) was used. Results of reduction at 37°C of 191 samples of raw milk show that triple strength solution increased the mean reduction times by 31 minutes to purple pink, 44 minutes to pink and 2 hours to white. Using single strength solution 48 per cent. of the samples reduced the dye within one hour whereas only 40 per cent were reduced in this time when triple strength solution was used. The reduction times obtained with triple strength solution are significantly slower than those obtained with single strength concentration and the results cannot be compared. Reduction times obtained with double strength concentration (1/110,000) were rarely half an hour slower and could not be considered significantly different from those obtained with the normal concentration.

Comparison of resazurin reduction at 37°C. and at room temperatures (15°—20°C).

Some of the early investigations on the use of resazurin for the grading of milk were carried out at room temperatures. Mojonnier Bros., Co., Milk Engineers, Chicago are now marketing equipment, including a simple colour chart for matching the colour, for their 'azurufin test' which they recommend for grading milk at room temperatures. Our comparative results (Table XVII) show that 83 per cent of the samples that were reduced to pink or white within 1 hour at 37°C were reduced to purple pink or beyond in one hour at 15° — 20°C. Thus the really poor quality samples were detected at room temperatures. As the tubes have to be held in the dark during the test some form of incubator or water bath is needed so that this method does not have any inherent superior qualities. Atmospheric temperatures as found in dark chambers or uncontrolled incubators fluctuate between rather wide limits so that the writers came to the conclusion that it is better to carry out the test at a definite standard temperature such as 30° or 37°C. Previous work carried out at this laboratory (Thomas et al. 1939) indicated that reduction at 30°C. was slower than at 37°C., whilst incubation at 21°C. (70°F) gives still slower reduction.

TABLE XVII.

Reduction within one hour at 37°C.	*Reduction to purple pink to white at room temperature*					*Total samples*
	1 hour	*2 hrs.*	*3 hrs.*	*4 hrs.*	*Over 4 hrs.*	
Blue	0	0	1	10	236	247
Purple pink	9	59	22	10	31	131
Pink	36	28	3	0	1	68
White	121	0	0	0	0	121
TOTAL SAMPLES	166	87	26	20	268	567

Thermophilic bacteria and resazurin reduction.

A series of raw milk samples were incubated in duplicate for 6 — 24 hours at 55° and 63°C. so as to encourage the development of thermophilic bacteria. Colony counts, methylene blue tests and resazurin tests were carried out at 55° and 63°C. The results given in Table XVIII show that samples with colony counts on milk agar at 63°C under 5,000 per ml. did not reduce methylene blue at 63°C. within 24 hours, whereas resazurin was reduced to purple pink in 3 — 5 hours at this temperature. Of the samples incubated and tested at 55°C., those with colony counts around 40,000 reduced methylene blue in 3½ hours and resazurin in 1 hour. Samples with very high thermophilic bacterial contents (400,000 to 2,000,000) reduced resazurin within 10 — 15 minutes compared with 40 — 60 minutes for methylene blue.

The use of resazurin reduction seems to have distinct advantages over methylene blue reduction for the detection of the activity of a thermophilic flora under 500,000 per ml.

Comparator readings.

The All Purposes Lovibond Comparator (or alternatively a simplified form suitable for this test only) mounted on a special stand designed by Mr. Fawcett of The Tintometer Limited, Milford,

TABLE XVIII.

Colony counts and reduction times at:—	*No. of samples*	*Mean colony counts*	*Mean methylene blue reduction (Hrs. and mins)*	*Resazurin reduction (Hrs. and mins.)*	
				Purple pink	*Pink*
63 °C.	10	130	24 : 00+	4 : 24	24 : 00+
,,	11	3,000	24 : 00+	3 : 15	24 : 00+
55 °C.	7	39,000	3 : 28	1 : 08	2 : 54
,,	13	428,000	0 : 55	0 : 10	2 : 25
,,	5	1,941,000	0 : 42	0 : 10	0 : 19

Salisbury, in collaboration with Dr. J. G. Davis of The National Institute for Research in Dairying, Reading, and the writers, has been used during the last six months of this work. The tube under examination is held obliquely under the viewing glass, whilst a control tube containing milk only is placed at the same angle under the colour discs. A white background is provided for both tubes. Six coloured discs mounted on a revolving wheel give blue to vivid pink standards (Table XX). The Comparator can be fitted to the white light cabinet of the Lovibond Tintometer. A comparison of colour grading without the comparator, to blue, purple pink and pink with comparator readings (Table XIX) shows that blue tubes are mostly placed in groups 1 and 2, purple pink in 3 — 4 and pink in 5 — 6, though some overlapping occurs particularly in the case of purple pink.

A comparison of comparator readings observed by 4, 3 and 2 workers (Table XX) shows that agreement is fairly good, being best in the blue and pink colours. The maximum variation obtained was ±1 disc reading. The continued use of such a comparator is essential for the standardisation of readings by different workers and at different laboratories. The results also show that there is no serious difficulty in obtaining reasonable matching of colours by a number of workers.

TABLE XIX.

Comparison of colour grading and comparator readings.

Colour grading without comparator	*Comparator readings*						*Total readings*
	1 *Blue*	2 *Lilac*	3 *Mauve*	4 *Purple pink*	5 *Pink*	6 *Vivid pink*	
Blue......	221	58	21				300
Purple pink		67	112	111	10		300
Pink				17	152	131	300
TOTALS	221	125	133	128	162	131	900

TABLE XX.

Reliability of Resazurin test.

Comparator discs		No. of readings	Similar readings					
			Four workers		Three workers		Two workers	
No.	Colour		No.	%	No.	%	No.	%
1	Blue	60	44	73	49	82	56	93
2	Lilac	51	26	51	34	67	43	84
3	Mauve	60	34	57	44	73	49	82
4	Purple pink	47	31	66	35	74	38	81
5	Pink	50	37	74	43	86	45	90
6	Vivid Pink	35	19	54	23	66	25	71
TOTAL		303	191	63	228	75	256	85

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References.

BAHR (1914). *Skand. Veter.*, 4, 28.
BARRETT, RUTAN and KEENAN (1937). *J. Dairy Sc.*, 20, 705.
BARTHEL (1917). *Z. Untersuch. Nahr. U. Genessm.*, 15, 385.
BRYAN and TROUT (1935). *J. Dairy Sc.*, 18, 777.
DAVIS and THEIL (1939). *Proc. Soc. Agr. Bact.*, p. 35.
DAVIS (1940). " Dairy Industries," January, 1940.
DAVIES, THOMAS, and THOMAS (1939). *Welsh J. Agric.* 15, 181.
DEVEREUX and BRYAN (1936). *Mich. Agric. Exp. Sta. Quart. Bull.*, 18, 161.
FRAYER (1930). *Vermont Agric. Exp. Sta. Bull.*, No. 313.
FRAYER (1938). *Vermont Agric. Exp Sta. Bull.*, No. 435.
KEENAN, BARRETT and RUTAN (1937). *J. Milk Tech.* October. p. 22.
MALCOLM and LEITCH (1936). *Scott. J. Agric.*, 19, 321.
MCCLEMONT and DAVIS (1939). *J. Dairy Res.*, 10, 88.
NELSON and FOLTZ (1938). *Rep. Kansas Agric. Exp. Sta.*, 1936-8. p. 89.
NICHOLS and EDWARDS (1936). *J. Dairy Res.*, 7, 258.
RAMSDELL, JOHNSON and EVANS (1935). *J. Dairy Sc.*, 18, 705.
RUSSELL, PALMER-JONES and MOIR (1939). *New Zealand J. of Sc. and Tech.*, 21, 161.
SKAR (1913). *Molkerei Ztg.*, 23, 374.
THORNTON and HASTINGS (1930). *J. Dairy Sc.*, 13, 221.
THOMAS, THOMAS and DAVIES (1939). *Proc. Soc. Agr. Bact.* p. 31.
WILSON, TWIGG, WRIGHT, HENDRY, COWELL and MAIER (1935). *Med. Res. Council Spec. Rept.*, Ser. No. 206.
WILLIAMS, DAVIES and THOMAS (1939). *Welsh J. Agric.* 15, 169.

THE INCIDENCE OF TUBERCLE ORGANISMS IN MILK PRODUCED IN MID-WALES.

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The chief object of this investigation, carried out during 1930-40, was to ascertain the extent of tubercle infection in bulk herd milk produced in the counties of Carmarthen, Merioneth, Cardigan, Brecon and Pembroke. In addition a number of samples taken aseptically from cows' udders suspected of having tubercular mastitis were examined, whilst during the last two years an investigation of the incidence of tubercle organisms in bulked creamery by-products has been carried out. Though the last investigation is only in its early stages it was considered that the results obtained so far would be of interest.

Samples of 100 ml. of well-mixed milk were centrifuged at 3,000 R.P.M. for half an hour. The sediment and some of the cream layer was mixed up with 9 ml. of saline, and 2 ml. were inoculated subcutaneously into each thigh of two guinea pigs. One animal was killed in six weeks; if positive, the other was killed immediately and, if negative, the other guinea pig was kept for eight weeks from the time of inoculation. On autopsy the presence of tubercle organisms in lesions was demonstrated microscopically and in any case of doubt as to the nature of the lesions, two more guinea pigs were subinoculated with material from the doubtful lesions. The results are given below :—

TABLE I.

Type of Milk	*Total No. of samples*	*Inconclusive results*		*Conclusive results*	*Tubercle positive samples*	
		No.	*%*	*No.*	*No.*	*%*
Bulk herd milk.						
Ungraded Raw milk	1,190	46	3.8	1,144	13	1.1
Accredited milk	434	4	0.9	430	2	0.5
School milk	123	0	0.0	123	4	3.2
Individual cows milk.						
Suspicious udders	123	2	1.6	121	23	19.0
Bulk creamery skim milk.						
Raw skim	65	3	4.6	62	4	6.4
Pasteurised skim	26	1	3.8	25	0	0.0

Bulk herd milk.

According to a survey of the literature made by the People's League of Health (1932), 6.7 per cent of 69,901 unselected samples of raw mixed milk as received at 18 of the larger towns in Britain during 1920-30 contained living tubercle organisms. Gloyne (1932) found 8.2 per cent positive out of a total of 1,560 raw milk samples produced in Essex. Fifty-two Grade A (T.T.) milk samples yielded two positives and 49 Grade A milks five positives. An inquiry conducted by the Department of Health for Scotland (1933) included the examination of 1,534 samples of raw milk consigned from farms to Aberdeen, Dundee, Edinburgh and Glasgow. Tubercle organisms were found in 10 per cent of these samples. Of 207 samples from bulked raw milk in tanks of about 500 gallons capacity, 37 per cent were positive, and it was found that as the bulking of the milk was reduced the incidence was correspondingly reduced. None of 329 Certified milk samples and only one of 385 Grade A (T.T.) milk samples were positive. Pullinger (1934) examined 101 samples of Certified or Grade A (T.T.) milk and only found one to be infected, whereas all of the 63 samples taken from 3,000 gallon rail tanks were tubercle positive. He also found that as many as 21 per cent of the 105 raw bulk milk samples taken in Cheshire were positive whilst only 2 per cent of 104 similar samples from Somerset were infected. Savage (1929) had previously reported that only 2.3 per cent of 1,327 bulk herd milk samples taken at Somerset farms, from all the milk producing cows in the herds, were positive. Rowlands (1933) examined 109 herd samples from North Wales and found 2.7 per cent positive.

Our results show that 1.1 per cent of ungraded raw milk samples from the farms were infected, whilst the relative incidence was only 0.5 per cent in the case of Accredited milk samples. Of a total of 1,574 Accredited and ungraded bulk herd milk samples, only 15 samples (0.95 per cent) were positive.

It is estimated on the basis of the tuberculin reaction, that at least 40 per cent of the cows in this country are infected with the tubercle bacillus, though only a minority of them are in an infectious condition. Certain areas in Wales, however, appear to have a much lower incidence. Thus Montgomery (1937) found that in four cattle breeding districts in North Wales comprising 28 farms with 594 cattle, the incidence was only 4.4 per cent. Thomas (1936) found that of 690 cattle belonging to 22 self-contained herds in Carmarthenshire, only 2.6 per cent reacted. The development of the Attested herds scheme (introduced under the Milk Act of 1934), which has been very striking in certain areas in Wales, may also be attributed to the low incidence of bovine tuberculosis.

Of 2,658 attested herds in the Principality on July 1st, 1939 (as compared with 1,517 in England), ninety-two per cent were located in Carmarthen and the adjoining counties of Pembroke and Cardigan.

Suspicious udders.

Of 121 aseptically drawn samples from udders considered abnormal by veterinary surgeons, 19 per cent showed the presence of tubercle organisms.

Bulk creamery skim milk.

The return for calf feeding of infected bulked creamery by-products such as skim milk, buttermilk and whey is considered to be one of the most likely methods of introducing tuberculosis into a herd. The high incidence of tubercle organisms in bulked milk or by-products led the Economic Advisory Council Committee on cattle diseases (1934) to recommend that no milk which has been held in any vessel containing more than 100 gallons of milk, unless derived from a single herd, be sold for consumption in liquid form unless it has been pasteurised. Russell (1907) has reported a very striking instance of the spread of bovine tuberculosis by the indiscriminate feeding of unpasteurised creamery by-products in Wisconsin. In the course of carrying out the tuberculin testing of cattle, he found that over 30 per cent of 1,213 cattle owned by the suppliers of two creameries that returned unpasteurised skim milk, were tubercular. Furthermore, the young stock raised on the farms were infected whereas animals that had been bought from outside the district were not infected. Only 8 per cent of 1,467 cattle tested in 78 herds whose owners patronised eleven neighbouring creameries reacted to the test.

Such information has resulted in American and European legislation requiring the pasteurisation of all creamery by-products returned to farms for feeding purposes. This has been enforced in some countries for over 30 years. Flash heating to 180°—185°F., which causes changes in the milk detectable by the Storch test has been generally advocated.

A survey of the methods used for the pasteurisation of skim milk and whey at 55 cheese factories and 40 butter factories and separating stations in the State of New York was carried out by Dotterrer and Breed as early as 1915. Roadhouse and Perry (1930) also describe simple and cheap methods which are being utilised for the pasteurisation of milk intended for calf feeding. They recommend heating at 160°—175°F. for at least 20 minutes.

In this country creamery by-products are commonly pasteurised by either injecting steam directly into the skim milk or whey or by heating at 165°—170°F. for 15 seconds in a high temperature short time pasteuriser. Mattick and Hoy (1939) discuss the bactericidal efficiency of heating skim milk and whey at 175°F. for 3 seconds by means of direct steam injection, using an adaptation of the plate type of heat exchanger. They found that heating for a few seconds at 168°F. and higher gave negative phosphatase test results.

Of 62 samples of raw skim milk taken from two creameries in Mid-Wales, 6.4 per cent were infected with tubercle organisms. Of thirteen samples taken from a bulk of 200—300 gallons at factory A., 3 (27%) were infected, whilst only one of the 52 samples taken from 400—1,000 gallons at factory B was positive.

None of the samples of bulked pasteurised skim milk obtained from three creameries in this area were infected. Application of the phosphatase test however showed that only 50 per cent of the samples were efficiently pasteurised. This was not unexpected as factory C was pasteurising by means of a steam hose in the churns and the temperatures attained showed much fluctuation. Flash heating to 150°F. was in use at factory D and only 16 per cent of the samples gave satisfactory phosphatase test results. The milk at factory E was heated to 165°—170°F. for 15 seconds and all the samples showed evidence of efficient pasteurisation.

References.

DEPARTMENT OF HEALTH FOR SCOTLAND (1933). *Spec. Rep. Ser. Med. Res. Counc.* No. 189.

DOTTERRER and BREED (1915). *N.Y. Agr. Exp. Sta. Bull.* No. 412.

ECONOMIC ADVISORY COUNCIL COMMITTEE ON CATTLE DISEASES (1934). H.M.S.O., London.

GLOYNE (1932). Tubercle. 13. 443.

MATTICK and HOY (1939). *Proc. Soc. Agr. Bact.* p. 27.

MONTGOMERIE (1937). *J. Roy. Sanit. Inst.* 57. 514.

PEOPLE'S LEAGUE OF HEALTH (1932). " A survey of tuberculosis of bovine origin in Great Britain." London.

PULLINGER (1934). *Lancet.* 226. 967.

ROADHOUSE and PERRY (1930). *Calif. Agr. Expt. Sta. Circ.* No. 319.

ROWLANDS (1933). *Vet. Rec.* 13. 127.

RUSSELL (1907). *Wis. Agr. Exp. Sta. Bull.* 143.

SAVAGE (1929). " The prevention of human tuberculosis of bovine origin." London. (Macmillan and Co.)

THOMAS (1936). *Vet. Rec.* 48. 241.

BACTERIOLOGICAL QUALITY OF DESIGNATED MILK.

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Previous reports on the results of the bacteriological examination of designated milk samples taken in Wales have been submitted by Thomas *et al* (1932), Thomas (1937) and Thomas and Hobson (1938). The present summary covers the three-year period subsequent to January 1st, 1937, when the modified methylene blue test allied with the coliform test was introduced as the official method of grading designated milk. The samples examined were derived from the nine Mid and South Wales counties comprising the Aberystwyth Bacteriological Advisory Area. All official " post licence " samples were taken and tested in accordance with the prescriptions laid down in the Ministry of Health Memorandum 139/Foods (1937).

The results obtained during the past 15 years are given in Table I. It will be observed that there has been a striking deterioration in the quality of graded milk in this area coincident with a rapid increase in the number of designated producers.

TABLE I.

Period	*No. of designated milk producers on June 1st*	*Official " post licence" samples examined*	*Samples failing to attain designated standards*	
			No.	*Per Cent*
1925-35	90	5,133	578	11.2
*1936	1,500	3,040	529	17.4
1937	2,000	2,501	708	28.3
1938	2,800	5,093	1,827	35.9
1939	3,534	4,825	1,508	31.2

**M.M.B. bonus on designated milk became available on April 1st, 1935.*

Previous to 1937, milk was officially tested by means of the colony count and coliform tests. The introduction of the new combination of methylene blue and coliform tests has not made any significant difference in the standard (Thomas and Hobson, 1938). The influence of seasonal factors (mainly temperature) on the quality of the milk is very evident (Table II). Very few samples failed to attain the desired standards during winter months, but the number of failures is very high during June—September. Of approximately 6,000 samples taken during November—April, 21 per cent failed compared with 44 per cent of 6,500 samples taken during the summer months (May—October). The worst period during each of the three years has been during August when the percentage failures ranged from 56 to 75. Advisory work has shown that this is due to inadequate cooling facilities and inefficient sterilisation of utensils.

TABLE II.

Tuberculin tested and accredited milk.

Month	*1937*		*1938*		*1939*	
	Samples examined	*% failing to attain standards*	*Samples examined*	*% failing to attain standards*	*Samples examined*	*% failing to attain standards*
Jan.	167	14.4	289	19.3	382	15.2
Feb.	224	4.9	399	13.0	549	16.6
March	189	7.9	362	22.3	580	16.0
April	83	7.2	285	21.4	318	26.4
May	282	30.5	641	25.9	576	27.3
June	200	39.0	384	47.4	616	44.0
July	196	52.5	466	53.6	383	42.0
Aug.	198	75.2	363	55.9	229	63.3
Sept.	208	45.2	604	52.0	369	44.1
Oct.	114	30.7	464	45.5	176	28.4
Nov.	371	22.4	508	37.6	445	43.6
Dec.	269	8.9	328	18.3	202	20.8
TOTALS	2,501	28.3	5,093	35.9	4,825	31.2

A comparison of the monthly results of the bacteriological examination of designated and undesignated milk is given in Table III. With the exception of suppliers' milk taken on arrival at three creameries in Mid Wales, all the samples were graded on methylene blue and coliform tests. The creamery samples were graded on methylene blue test only. Twenty-eight per cent of the tuberculin tested milk samples failed as compared with 33 per cent of accredited milk samples. The superior quality of the former grade is most noticeable during the warmer months—June to September. All producers of tuberculin tested milk use steam for the sterilisation of utensils and they cool the milk to 50°—60°F. as soon as possible after milking, whereas a large proportion of the accredited milk producers do not carry out these essential processes in anything like an efficient way.

The county authorities take one or more milk samples prior to granting a designated licence. It is interesting to note that the quality of these pre-licence samples is superior to that obtained

TABLE III.

Designated and Undesignated Milk, 1937-1939.

Month	*Tuberculin Tested*		*Accredited milk*		*Pre-licence samples*		*School milk samples*		*Undesignated Milk (Pub. Hlth. Auth.)*		*Supplier's Milk at creameries*	
	Samples examined	*% failing*	*Samples examined*	*% failing*	*Samples examined*	*% failing*	*Samples examined*	*% failing*	*Samples examined*	*% failing*	*Samples Examined*	*% failing*
Jan.	98	15	740	17	125	9	58	41	51	34	180	4
Feb.	171	14	1,001	13	86	8	70	36	40	30	180	20
March	207	10	924	18	78	10	63	35	109	40	180	38
April	128	30	558	20	52	8	29	34	102	45	286	42
May	155	22	1,344	28	91	19	85	31	136	52	343	39
June	184	33	1,016	46	98	21	82	48	211	70	76	85
July	170	44	875	50	163	42	58	45	135	77	578	91
Aug.	157	57	639	64	129	49	6	17	62	82	297	88
Sept.	191	36	990	51	105	30	76	43	113	73	32	56
Oct.	119	26	635	42	116	25	37	67	100	63	194	47
Nov.	161	28	1,163	36	93	15	70	48	122	49	180	53
Dec.	112	17	687	16	118	16	41	29	112	27	180	32
TOTALS	1,847	28	10,572	33	1,324	22	675	41	1,293	56	2,706	53

for official quarterly samples of tuberculin tested and accredited milk. This is presumably due to the special effort made during the period prior to qualification for a licence.

The school milk samples were taken on the arrival of the milk at a number of schools in Mid and South Wales. A considerable proportion of these supplies were of tuberculin tested or accredited milk, but in the outlying rural areas undesignated milk of poor quality was being supplied. Thus as much as 41 per cent of the samples examined were unsatisfactory. Results for undesignated raw milk samples taken by public health authorities and for supplier's milk sampled on arrival at milk factories show that designated milk is much superior in bacteriological quality. Only 18—30 per cent of the undesignated milk and 9—15 per cent of the factory supplies attained designated standards during June—August.

Morning's milk samples were held at atmospheric temperature until 6 p.m., when they were placed in a refrigerator run at 40°F. and stored at this temperature overnight; the tests being set up at 9—10 a.m. the following morning. Evening's milk, on the other hand, was held at atmospheric temperature from the time of production until 9—10 a.m. the following morning when it was examined. When the results over the whole season are considered (Table IV) there does not appear to be much difference in the quality of morning and evening milk, but more morning's milk samples failed during cold weather (Nov.—Jan.). It is difficult to account for this significant difference, but it is suggested that it may be due to an actual difference of quality of the milk on production. The utensils may not be so carefully washed and sterilised after the evening's milking, particularly during the dark winter evenings, as is the case after the morning's milking. This could account for a higher bacterial content in morning's milk.

TABLE IV.

Season	*Morning's milk*			*Evening's milk*		
	Samples examined	*Failures*		*Samples examined*	*Failures*	
		No.	%		*No.*	%
Nov.—Jan.	2,498	655	26.2	463	77	16.6
Feb.—April	2,411	402	16.6	578	92	15.9
May—July	3,009	1,141	37.9	735	312	42.4
Aug.—Oct.	2,077	1,054	50.7	648	310	44.7
TOTAL	9.995	3,252	32,5	2,424	791	32,6

The significance of the use of the coliform test in addition to methylene blue reduction is shown in Table V. When both tests were used 32 per cent of the samples examined were unsatisfactory. If the grading had been carried out by means of the methylene blue test alone, only 19 per cent would have been failed. The ratios of failures on both tests compared with failures on methylene blue show that little over half the failures were obtained when the latter was used alone, and was actually under 50 per cent during December and January.

TABLE V.

Month	*Total No. of samples examined*	*Samples failing to attain designated milk standards on :—*						*Ratios of failures on M.B. and/or Coliform test to M.B. test only*
		Methylene blue and/or Coliform test		*Methylene blue test*		*Coliform test only*		
		No.	%	*No.*	%	*No.*	%	
Jan.	838	138	16.5	65	7.8	73	8.7	100 : 47
Feb.	1,172	154	13.1	93	7.9	61	5.2	100 : 60
March	1,131	188	16.2	129	11.4	59	5.2	100 : 68
April	686	152	22.2	87	12.7	65	9.5	100 : 57
May	1,499	409	27.3	212	14.1	197	13.1	100 : 51
June	1,200	530	44.1	318	26.5	212	17.7	100 : 60
July	1,0 5	514	49.2	314	30.0	200	19.1	100 : 61
Aug.	790	497	62.9	341	43.2	156	19.8	100 : 69
Sept.	1,181	571	8.3	338	28.6	233	19.7	100 : 59
Oct.	754	296	39.3	117	15.5	179	23.2	100 : 39
Nov.	1,324	468	35.3	323	24.4	145	10.9	100 : 69
Dec.	799	126	15.7	55	7.0	71	9.0	100 : 43
TOTAL	12,419	4,043	32.5	2,392	19.3	1,651	13.3	100 : 59

According to the Milk (Special Designations) Order, 1936, pasteurised milk must not contain more than 100,000 colonies of bacteria developing on milk agar incubated for 2 days at 37°C. The results of applying this official test, together with the present unofficial coliform and phosphatase tests on samples of pasteurised milk delivered to schools in the advisory province are shown in Table VI. Only 25 per cent of the samples failed officially on the colony count. This compares very favourably with the results for raw milk supplied to schools, 41 per cent of which were unsatisfactory. Fifty per cent of the pasteurised milks however showed the presence of coliform organisms in 1/10 ml.

The results of the phosphatase test show a gradual but very striking improvement in the efficiency of the pasteurisation of these school milks since 1938. Thus only 56 per cent of the samples examined during 1938 were considered to be efficiently pasteurised, whereas the relative figure for 1939 was 82 per cent. Of the 117 samples examined during 1938-40, 74 per cent are considered to have been efficiently pasteurised, 19 per cent seem to indicate some error in the pasteurising technique, whilst only 6 per cent show serious errors in heat treatment.

TABLE VI.

Pasteurised milk supplied to Schools.

Year	*Samples examined*	% *samples with plate counts over* 100,000 *per ml.*	% *Coliform positive in* 1/10th *ml.*	*Phosphatase Test*		
				Lovibond blue units		
				% *below* 2.3	% *between* 2.3—6.0	% *over* 6.0
1938	48	23.0	52.0	56.0	29.0	15.0
1939	51	25.0	49.0	82.0	17.0	0
Jan.-May, 1940	18	33.0	44.0	100.0	0	0
TOTAL	117	25.0	50.0	74.0	19.0	6.0

References.

MIN. OF HEALTH MEMORANDUM (1937). Memo. 139/Foods. H.M.S.O., London.

THOMAS, (1937). *Welsh J. Agric.* 13. 282.

———... HICKSON, SUGDEN, CATTO and SLADDEN (1932). *Welsh J. Agric.* 8. 214.

———..., and HOBSON (1938). *Welsh J. Agric.* 14. 247.

THE COMPARATIVE STERILITY OF MILK BOTTLES AND MILK CARTONS.

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This investigation was carried out with pint bottles and cartons taken at random from 24 farms and dairies during summer months. The bottles were capped, taken to the laboratory and examined within 4—6 hours after sterilisation. The cartons were closed and tested for sterility within a few hours.

Fifty millilitres of quarter strength Ringer's solution and some sterile glass beads were added to each container which was then closed and shaken vigorously 25 times. After standing for about 30—40 minutes the containers were again shaken 25 times. Ten ml. 1 ml. and dilutions of 1 ml. were then plated on milk agar and the colonies counted after incubation for 3 days at 37°C. The results are given in Tables I and II.

TABLE I.

Pint Bottles.

Source	*No. of bottles examined*	*Mean count per bottle*	*Percent. samples with colony counts per ml. capacity of container :—*		
			Not more than 1	*2—20*	*Over 20*
			Satisfactory	*Unsatisfactory*	*Highly contaminated*
Washed but unsterilised bottles returned by consumers	24	172,000	0	0	100
Farms with hot water sterilisation	96	46,500	0	17	83
Farms with steam sterilisation	48	10,200	19	54	27
Town dairies (steam sterilisation)	18	630	44	56	0
College Dairy (steam sterilisation)	72	470	63	36	1

TABLE II.

Pint Cartons.

Source	No. of cartons examined	Per cent samples with colony counts per ml. capacity of container :—			
		Mean count per carton	Not more than 1	2—20	Over 20
			Satisfactory	Unsatisfactory	Highly contaminated
Farms and dairies	70	315	69	27	4
Direct from carton manufacturers	10	50	100	0	0
TOTAL	80	243	72	24	4

The efficiency of the cleaning and sterilising process is generally measured by the production of containers having a residual bacterial colony count of not more than one per millilitre of capacity (U.S. Ordinance and Code, 1936, and Hannah Dairy Res. Inst. Bull. No. 6, 1935). Mattick and Hoy (1937) have however suggested a stricter standard of not more than 200 colonies per bottle, that is 1/3rd colony per ml. of capacity for pint bottles.

An examination of the results shows that the bacterial content of the cartons was much less than that for the most efficiently sterilised bottles. A number of clean bottles returned to the roundsmen by consumers were examined. These had evidently been thoroughly washed, but would not have been sterilised, though hot water and soda was used by some of the consumers. The (geometric) mean count of 24 such bottles was 172,000 and they thus contained 300 organisms per ml. of bottle capacity. Bottles taken from farms attempting to sterilise bottles by means of boiling water were all unsatisfactory, 83 per cent being highly contaminated. A large proportion of bottles sterilised in farm steam chests were also found to be unsatisfactory, but bottles from town dairies using steam were more satisfactory. Seventy-two bottles were sterilised in the college dairy steam chest at approximately 210°F. for 15 minutes. The mean count per bottle was quite low, but exceeded the standard suggested by Mattick and Hoy (1937) and 37 per cent of the bottles examined contained more than one colony per ml. of bottle capacity. Of 70 cartons taken from farms and dairies, only 31 per cent exceeded the suggested bacterial standard, whilst the mean colony count per container was only 315. It was observed that partly used nests of cartons were unpacked and often left for

12—14 hours in dusty surroundings. The examination of 18 top cartons showed the presence of as much as 2,800 colonies per carton as compared with 145 colonies per carton for 52 lower cartons. Similar results were obtained by Speck and Black (1937). The mean count for ten cartons sent direct from the manufacturers was 50 colonies per container and none contained more than one colony per ml. of carton capacity. Sanborn, Yale and Breed (1938) have suggested that the average bacterial content of paper milk containers should not exceed 50 colonies per container.

The effectiveness of the rinsing method was tested by rinsing five bottles four times in succession, allowing a soaking period of 20 minutes after each shaking.

Rinsing	*Mean colony count per bottle*
First	5,200
Second	630
Third	2,220
Fourth	2,060

Thus only 51 per cent of the total organisms removed were obtained in the first rinsing. The need for improved standard procedures for testing the effectiveness of the cleaning and sterilisation of dairy utensils and food containers is very obvious.

References.

MATTICK and HOY (1937). " Bottle washing and bottle washing machines." *Pub. N.I.R.D.* Shinfield, near Reading.

SANBORN, YALE and BREED (1938). *J. Milk Tech.* Vol. I. No. 5. p. 53.

SPECK and BLACK (1937). Food Res. 2, 559.

SCOTT and WRIGHT (1935). *Bull. Hannah Dairy Res. Inst.* No. 6.

U.S. MILK ORDINANCE AND CODE (1936). Treasury Dept. Pub. Hlth. Service, Washington, D.C.

AGRICULTURAL BOOKS, 1939.

The following list, prepared by the staff of the National Library of Wales, is a selection of the more important books on the science and practice of agriculture published during the year 1939, together with a few omitted from the list for 1938. The list supplements *The Hand List of Books on Agriculture* issued by the National Library, third edition, 1926, copies of which can be obtained on application to the Librarian, The National Library of Wales, Aberystwyth.

Adriance, G. W., *and* Brison, F. R. Propagation of horticultural plants. New York: McGraw-Hill, 1939. pp. x, 314. front., ill., bibl.	$3.00
Astor, W., *2nd Viscount, and* Rowntree, B. S. British agriculture: the principles of future policy. A report of an enquiry. . . . London: Longmans, 1938. pp. xx, 470.	15s. 0d
Ayres, O. C., *and* Scoates, D. Land drainage and reclamation. . . . *2nd ed.* New York: McGraw-Hill, 1939. pp. xii, 496. ill., diags., maps. bibl.	$4.00
Bagenal, N. B. *Editor.* Fruit growing. . . . London: Ward Lock, 1939. pp. 400. col. front., col. pls., ills., diags.	21s. 0d.
Barton, F. T. Cattle, sheep, and pigs. . . . *3rd ed.* London: Jarrolds, 1939. pp. 270. front., ill.	7s. 6d.
Bennett, H. H. Soil conservation. New York: McGraw-Hill. 1939. pp. xviii, 994. ill.	$6.00
Davies, W. L. The Chemistry of milk. . . . *2nd ed.* London: Chapman and Hall, 1939. pp. xiv, 534. bibl.	25s. 0d.
Dawson, C. D., *and* Dorn, M. V. Plant chemiculture. . . . *3rd ed.* Los Angeles: The Authors, 1939. pp. 130. front., ill., bibl.	$1.00
Ellis, C., *and* Swaney, M. W. Soil-less growth of plants. . . . New York: Reinhold Publ. Corp., 1938. pp. 156. col. front., col. pls., ill.	$2.75
Gardner, V. R., *and others.* The Fundamentals of fruit production by V. R. Gardner, F. C. Bradford and H. D. Hooker. *2nd ed.* New York: McGraw-Hill, 1939. pp. xvi, 788. ill., diags., bibl.	$5.00

GODWIN, G. The Land our larder: the story of the Surfleet experiment. London: Acorn Press, 1939. pp. xiv, 218. ill., bibl.	3s. 6d.
GUISE, C. H. The Management of farm woodlands. New York: McGraw-Hill, 1939. pp. x. 352. front., ill., maps, diags., bibl.	$3.00
HAGEDOORN, A. L. Animal breeding. London: Crosby Lockwood, 1939. pp. 304. ill., diags., bibl. ..	15s. 0d.
HALL, *Sir* A. D. Agriculture in the twentieth century: essays . . . to be presented to Sir D. Hall. Oxford: Clarendon Press, 1939. pp. x, 440. front. (port.).	15s. 0d.
HARLAND, S. C. The Genetics of cotton. London: Jonathan Cape, 1939. pp. 194. diags., bibl. ..	10s. 6d.
JACKS, G. V., *and* WHYTE, R. O. The Rape of the earth. . . . London: Faber and Faber, 1939. pp. 314. front., ill.	21s. 0d.
JONES, M. M. Farm shop practice. New York: McGraw-Hill, 1939. pp. xiv, 316. diags.	$2.75
KEEBLE, *Sir* F. W. Science lends a hand in the garden. London: Putman, 1939. pp. [xii], 308. ..	10s. 6d.
LAWRENCE, W. J. C. Practical plant breeding. . . . *2nd ed.* London: Allen and Unwin, 1939. pp. 156. ill., diags., bibl.	5s. 6d.
LAWRENCE, W. J. C., *and* NEWELL, J. Seed and potting composts, with special reference to soil sterilisation. London: Allen and Unwin, 1939. pp. 128. front., ill.	3s. 6d.
MACAULAY INSTITUTE FOR SOIL RESEARCH. Collected papers. Vol. I. Edit. by W. G. Ogg. Aberdeen: The Institute, 1938. ill.	21s. 0d.
MARSHALL, R. C. Silviculture of the trees of Trinidad and Tobago. . . Oxford: University Press, 1939. pp. xlviii, 248. front., pls., ill., maps.	21s. 0d.
MARLIN, D. R. Growing plants without soil. . . . London: Spon, 1939. pp. [viii]. 140. front., ill.	10s. 0d.
OXFORD UNIVERSITY. *Agricultural Economics Research Institute.* Milk Investigation Scheme. Costs of milk production in England and Wales. Interim Reports Nos. 3 and 4. Oxford: The Institute, 1939. 2 vols.	1s. 6d. each vol.

Page, J. W. From hunter to husbandman. London: Harrap, 1939. pp. 256. ill., maps., bibl., diags.	7s. 6d.
Phillips, A. H. Gardening without soil. London: Pearson [1939]. pp. 138. front., pls., diags. ..	3s. 6d.
Sanders, H. G. An Outline of British crop husbandry. Cambridge: University Press, 1939. pp. viii, 348. bibl.	15s. 0d.
Snapp, R. R. Beef cattle. . . *3rd ed.* New York: Wiley, 1939. pp. x. 550. front., ill., bibl.	$4.00
Stapledon, *Sir* R. G. The Plough-up policy and ley farming. London: Faber and Faber, 1939. pp. 170.	2s. 6d.
Talbert, T. J., *and* Murneek, A. E. Fruit Crops. . . . London: Bailliere, Tindall and Cox, 1939. pp. 346. ill., bibl., maps.	19s. 0d.
Thompson, H. C. Vegetable crops. . . *3rd ed.* New York: McGraw-Hill, 1939. pp. xii, 578. ill., bibl.	$5.00
Turner, W. I., *and* Henry, V. M. Growing plants in nutrient solutions. . . New York: Wiley, 1939. pp. xiv, 154. front., pls., ill., diags., bibl. ..	$3.00
Turnor, C. Yeoman calling. London: Chambers, 1939. pp. 288. front., pl., diags., plans. ..	7s. 6d.
Westveld, R. H. Applied silviculture in the United States. New York: Wiley, 1939. pp. viii, 568. ill., map. bibl.	$5.00
Winters, L. M. Animal breeding. . . . *3rd ed.* New York: Wiley, 1939. pp. viii, 316, front., ill., diags., bibl.	$3.50
Wormald, H. Diseases of fruits and hops. London: Crosby Lockwood, 1939. pp. 290. ill., diags., bibl.	17s. 6d.
Wright, C. H. Soil analysis. . . . *2nd ed.* London: Murby, 1939. pp. x, 276. diags.	12s. 6d.

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